



**MATHEMATICAL ASSOCIATION OF NIGERIA
(M.A.N)**

abacus

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MATHEMATICAL ASSOCIATION OF NIGERIA**

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Editor-in-Chief:

Professor Muhammad Lawan Kaurangini, FICA

Aliko Dangote University of Science and Technology, Wudil, Nigeria



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EDITORIAL

The Editorial Board is pleased to present **Volume 48, Number 3 (December 2023)** of *ABACUS: Journal of the Mathematical Association of Nigeria (Education Series)*. This edition continues the journal's commitment to advancing scholarship, research, and professional practice in Mathematics Education within Nigeria and the global academic community.

Mathematics education remains a vital instrument for national development, scientific literacy, technological advancement, and human capacity building. In an increasingly dynamic and technology-driven world, the teaching and learning of mathematics require innovative pedagogical approaches, curriculum reforms, effective assessment strategies, and the integration of modern educational technologies. The papers featured in this volume address these critical issues and contribute meaningfully to ongoing discussions aimed at improving mathematics teaching and learning at all levels of education.

This issue contains scholarly articles covering diverse themes in mathematics education, including teaching methodologies, curriculum development, students' achievement and attitudes, teacher preparation, instructional materials, educational technology, assessment practices, and related interdisciplinary studies. The contributions reflect current trends and emerging perspectives in mathematics education research and practice, while also offering practical recommendations for teachers, researchers, curriculum planners, and policymakers.

The Editorial Board remains committed to maintaining high academic and ethical standards in the publication process. Every manuscript published in this issue underwent a rigorous peer-review process to ensure originality, relevance, scholarly quality, and contribution to the field of mathematics education.

We sincerely appreciate the authors for their valuable submissions and the reviewers for their thoughtful evaluations and professional dedication. We also acknowledge the support of the **Mathematical Association of Nigeria (MAN)** for its continued efforts toward promoting mathematics education, research, and professional development in Nigeria.

As we conclude the 2023 publication cycle, we encourage researchers and educators to continue engaging in innovative and impactful studies that will strengthen mathematics education and contribute to educational transformation. It is our hope that this volume will serve as a useful academic resource and stimulate further research and collaboration among scholars and practitioners.

We thank our readers and contributors for their continued confidence in *ABACUS* and wish everyone a productive and rewarding academic year ahead.

Professor Muhammad Lawan Kaurangini

Editor-in-Chief

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- (1) a title of paper which well reflects the contents of the paper (Arial, 12pt),
- (2) all the name(s) and affiliations(s) of authors(s) (Arial, 12pt),
- (3) an abstract of 100-250 words (Times New Roman, 11 pt),
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Tables and figures: Tables and figures should be consecutively numbered and have short titles. They should be referred to in the text as following examples (e.g., Fig. 1(a), Figs. 1 and 2, Figs. 1(a)-(d) / Table 1, Tables 1-2, etc). Tables should have borders (1/2pt plane line) with the captions right before the table. Figures should be properly located in the text as an editable image file (.jpg) with captions on the lower cell.

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All the submitted papers will undergo a peer-review process, and those papers positively recommended by at least two expert reviewers will be finally accepted for publication in the Abacus Journals or after any required modifications are made and a payment of **₦15,000.00** as publication fee. The normal length of the paper should be between 8 to 12 pages. Any extra page will attract additional charges at the rate of **₦500.00** per page.

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EFFECT OF GEOMETRY PAD SOFTWARE ON STUDENTS' ACADEMIC ACHIEVEMENT IN COORDINATE GEOMETRY IN TOTO, NASARAWA STATE, NIGERIA

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Abstract

This study investigated the "Effects of Geometry-Pad Software on Students' Achievement in Geometry in Toto, Nasarawa State, Nigeria". The study adopted a quasi-experimental research of pre-test, post-test, non-equivalent, non-randomized, control groups design. The population for the study consists of 1,110, SS II students. Simple random sampling techniques was used to select intact classes of 110 students as sample for the study. Two research questions were raised and two null hypotheses were formulated for the study. Descriptive statistics of mean and standard deviation was used to answer research questions, while inferential statistics of t-test analysis was used to test the null hypotheses at 0.05 level of significant. The findings revealed that there is significant difference between the performance of students exposed to Geometry Pad Software and their counterpart exposed to Conventional Method in favour of experimental group. Also, the findings revealed that there is no significant difference between male and female student's achievement on geometry using Geometry Pad Software. Hence the researcher recommended that the use of Geometry Pad Software should be adopted for teaching/learning of geometry concepts in the secondary schools, In-service training programmes for Mathematics Teachers in form of workshops, seminars and conferences should be organised to focus more on how to use Geometry Pad Software in Teaching geometry concepts, among others.

Introduction

Mathematics is primarily concerned with ideas, processes and reasoning leading to the solution of problems. It is widely recognized as a necessary tool for achieving the developmental goals of any society. Good knowledge of Mathematics implies the growth of science and sustainable development of a nation. Teaching and learning of Mathematics and other science subjects form the bedrock that provides the springboard for developed and developing nations (Akwagha, 2019). Muawiya (2019) affirmed that the sustainable

development of any nation depends on the degree and extent of the socio-cultural, social economy and political improvement that brought about entrepreneurship in science, technology and Mathematics education. Mathematics plays an important role as the gateway to others fields of endeavour or sectors such as: Health, Agriculture, political, cultural, economics, educational and other sectors. It has a pride of place in the global world and in nation building when its contents and applications to real life situation are observed (Shuaibu, 2016). The need to acquire

knowledge in Mathematics in the world over has become very obvious and necessary because of its relevance to everyday life in our society today. This explains why it has been a compulsory subject both at the primary and secondary levels of education in Nigeria (Adams, 2020).

According to the Partnership for 21st Century Skills (2019), schools today are faced with ever-increasing demands in their attempt to ensure that students are well equipped to enter the workforce and navigate a complex world. Adams (2020) Research study indicates that computer technology can help support learning and that it is especially useful in developing the higher-order skills of critical thinking, analysis and scientific inquiry using Artificial Intelligence. Mathematics is referred to as a complex and difficult subject by some students, which made them end off considering the subject as boring, thus, creating a lack of attitude in the concepts taught. This poses a great challenge for teachers, especially in the primary and secondary levels.

Therefore, Geometry-Pad Software was adopted to support the realization of the above concerns. This Software connects features of the Computer Algebra System (CAS), Interactive Geometric Software (IGS) and spreadsheet and Geometry-Pad Software provides this functionality within in intuitive, user-friendly interface. It is an appropriate software for overcoming several difficulties, false beliefs, negative attitudes in coordinate geometry classroom. The overall teaching approach brings about new contextualized organization for geometry concepts which enable students to pass through the phases of

discovering geometrical concepts and theorems as well as attaining the level of proving.

The teaching of geometry is unique in process and practice. They require a manipulative and constructive approach that makes the concepts concrete and practical. On this premise, the use of innovation strategies like the electronic classroom, virtual laboratory, virtual library and Softwires are giving upper hands in Nigerian classrooms.

In view of the foregoing, prompted the researcher to investigate the effect of Geometry-Pad Software on students' academic achievement in geometry in Toto, Nasarawa State, Nigeria.

Geometry is the branch of Mathematics which deals with the relationship of lines, angles and surfaces. Geometry is also a concept of enjoyment and excitement, which offers students opportunities for creative work and moments of enlightenment and joy. Geometry starts from what you can see, touch or feel, for any strategy of teaching geometry to be effective and meaningful at the formative stage, the strategies must have those factors that will exchange the participation of student (student-centred) in the classroom. When ideas are discovered and insights gained, students are spared to pursue Mathematical knowledge beyond the four corners of the classroom walls science practical approach is being used as teaching method.

The teaching and learning of geometry have been the subject of concerns nationally and internationally, with many questions were raised about the appropriate teaching methods and curriculum design, with a view to

informing the development of better pedagogical models and instructional strategies. Geometry conception has been considered as a bases for learning Mathematics. Geometry was perceived as difficult concept by most of the students (Akwagha, 2019). Akwagha, (2019) suggested that an essential teaching approach used by Mathematics teachers at senior secondary school level is an approach that aims mutually to reinforce practical approaches in order to develop students thinking, particularly in the transition to Geometrical shapes. Learner should be given the opportunity to learn about these shapes. The present research work will consider the teaching of coordinate geometry concepts in senior secondary school (SS II) level in Toto, Nasarawa state. Below are the topics to be consider thus; Identification of cartesian plane, Location of two or more points on the cartesian plane, calculation of distance between two or more points on the cartesian plane, calculation mid-point between two points on the cartesian plane and calculation of gradient on the cartesian plane are coordinate geometry concepts that will be considered in terms of teaching using Geometry-Pad Software for effective learning. The use of Geometry-Pad Software as practical work and use of technological software is also part of the learning experience of the students.

Academic Achievement can be referred to as the students overall learning experience resulting in an observable and measurable behaviour change, which includes the requisition of specific ideology, skills and techniques at the end of a teaching and learning situation (Muawiya, 2019). Quite a number of definitions of achievement exist in

literature and most of these make attempt at comparing the essences of the concept. Musa (2023) define achievement as the event to which a person has achieved something acquired certain information or mastered certain skills, usually as a result of planned instruction or training. Akwagha, (2019) sees academic achieved as an assessment of how people have learnt or attained after a learning period. The degree of student's learning is determined by the learner's achievement through test. These tests provide means of evaluating students' activities in a programme. In view of the above, the researchers wish to investigate students Achievement when taught geometry using Geometry Pad software. Students' achievement can easily be enhanced through effective use of methods of teaching by teachers, and also use of student-centred and activity-based strategies also help in improving students' achievement in geometry and in other subject area.

There is general belief that male students perform better in Geometry concepts and mathematical-related subjects than the female students. A number of studies have looked into the influence of gender and environment on Geometry achievement of students. Musa (2021) emphasized such imbalance in male-female performance in science-related descriptions and stressed its significance as a new country rolled in. Adams (2020) reported that male students performed better at higher level of Mathematics than female students. Other findings which support male superiority were that of Isah (2016), Aliyu (2023) and Muhammed (2023) opined that the achievement gap of male and female in Mathematics is interesting in the fact that girls typically have better grades in Geometry

classes, but tend to scores lower on standardized Mathematics test. On this premises therefore, the researcher deemed it necessary to determine the gender achievement among students because gender is part of the variable to be investigated under the study. A very current and innovative strategy can equally bring out best among male and female students in classroom situation if properly utilized. Therefore, the researcher looks into the gender and achievement in geometry using Geometry-Pad Software.

Statement of the Problem

Many students in post-primary school today have a negative attitude towards learning Mathematics. The current obvious situation in Mathematics is the staggering decline in the achievement of learners at all levels of education (Musa and Umar, 2023). This poor achievement lies in the fact that most teachers use a deductive teacher – centred approach. Use of teacher-centred and non-activity-oriented approach of teaching by Mathematics teachers does not give room for students' participation in the classroom activities and they find it difficult to simulate the interest of the students during the instructions, so that they appreciate the subject, learn the concepts very well and apply the knowledge acquired in real life situation. Inability of the teacher to improvise relevant teaching materials is also a problem especially where the conventional ones are not available, as such the stated objectives of the lesson could not be achieved. Also, the use of only the older educational resources like textbook, charts, chalkboard, workshop/laboratory facilities in mathematics

curriculum delivery using teacher-centred approach in teaching are no longer enough to cope with in this world of computer and internet age. The strategies used by most Mathematics teachers to teach coordinate geometry concepts has create a lot of gaps between the learner and the concepts learnt. The possible way this gap created by use of inappropriate method could be minimize by adopting Geometry Pad Software by the mathematics teacher in an attempt to raise students' achievement in coordinate geometry, teaching geometry concepts using modern technology software make learning easier and permanent in them.

Therefore, based on the above, the researcher wishes to investigate the effects of Geometry pad Software on Students' Achievement in Geometry in Toto, Nasarawa State, Nigeria. The problem of this study is how to provide evidence on the effect or otherwise of the use of Geometry Pad Software on Students' Achievement in Geometry.

Objectives of the Study

The main objective of this study is to investigate the effect of Geometry Pad Software on Students Achievement in Geometry among Senior Secondary Students in Toto, Nasarawa State, Nigeria.

Specifically, the objectives of the study are to:

1. Determine the achievement of students taught Geometry using Geometry Pad Software and Conventional method.
2. Find out the effect of Geometry Pad Software on the achievement of male and female students in geometry.

Research Questions

To achieve the stated objectives of the study, the following research questions were raised to guide the study:

1. What are the mean achievement scores of students taught geometry using Geometry Pad Software and those taught using Conventional Method?
2. What are the mean achievement scores of male and female students taught geometry using Geometry Pad Software?

Statement of the Hypotheses

Base on the objective of the study, the following null hypotheses were formulated and would be tested at 0.05 level of significance

- Ho₁: There is no significant difference in the mean achievement scores of students taught geometry using Geometry Pad Software and those exposed to Conventional Method.
- Ho₂: There is no significant difference in the mean achievement scores of male and female students taught geometry using Geometry Pad Software.

Methodology

A quasi-experimental research design of pre-test, post-test nonrandomized control type was adopted for the study. The population of this study comprised of (1,110) SSII students in (12) public secondary school students in Toto, Nasarawa State. The choice of this population

is because the concept of geometry is mostly taught in SSII levels. And the sample for this research consist of 110 SSII senior students. Simple random

sampling technique was used to select one intact class each from two schools chosen from 12 public senior secondary schools in Toto, Nasarawa State. Two public senior secondary schools were randomized and assigned experimental and control groups respectively. The experimental group consist 63 students (38 males & 25 females) which were exposed to Geometry Pad Software while the control group 47 students (26 males & 21 females) were exposed to lecture method.

The instruments for data collection is Geometry Achievement Test (GAT). The GAT items consist of 15 multiple choice questions. The instruments were validated and reliable index of $r = 0.78$ was found using Pearson Product Moment Correlational Coefficient (PPMC). Pre-test was given to both Experimental and Control groups to determine the level of their prior academic achievement geometry before treatment. The geometry concepts were taught using Geometry Pad Software to experimental group while lecture method was used to teach control group. Lesson plans were designed for both experimental group and control group. The two groups had treatment for 5 weeks in third term 2023/2024 academic session respectively to determine the significant difference in academic achievement between the two groups as well as gender difference.

Experimental Procedure for Geometry Pad Software

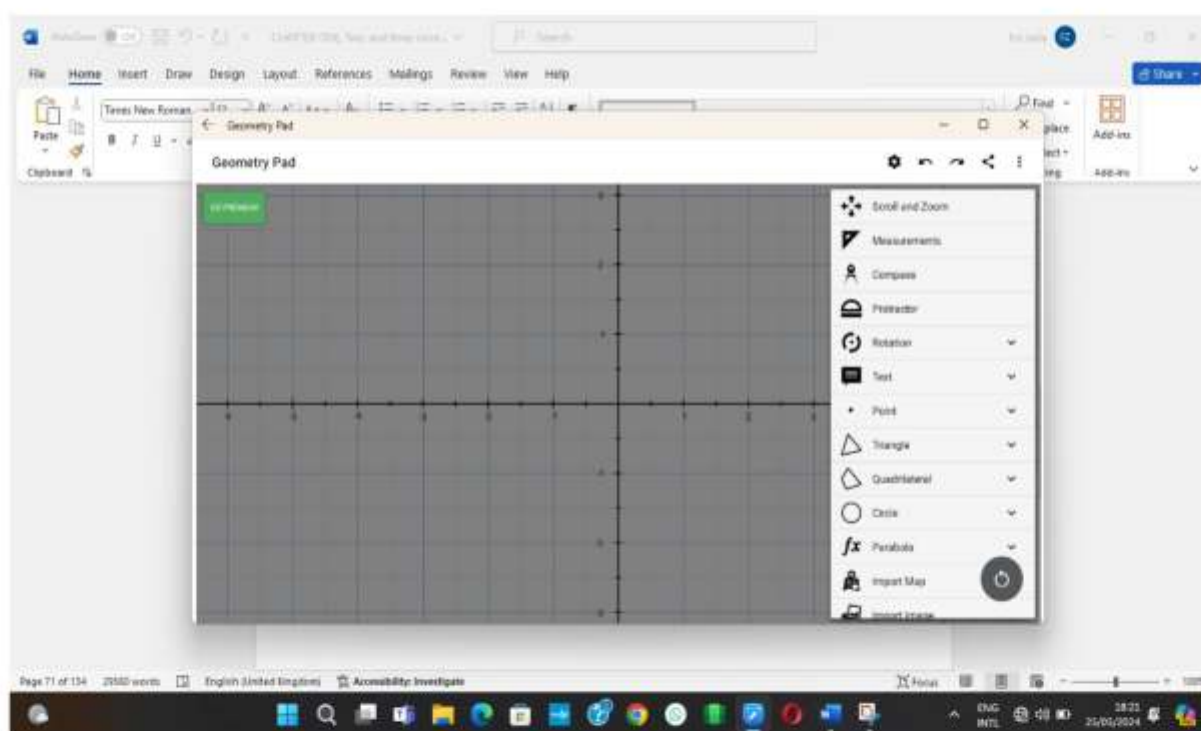
Teachers who are trained on the use of Geometry Pad Software will follow these steps:

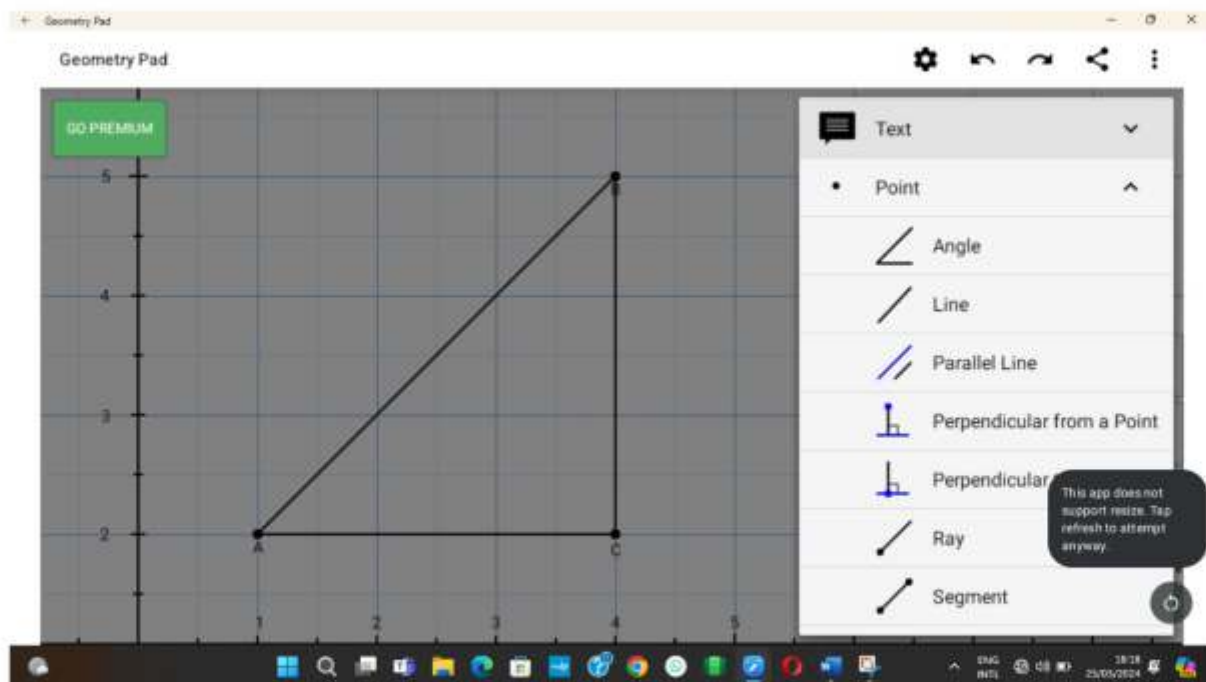
Step One: Teacher take the students to their computer laboratory equipped with overhead projector and computer system; individual students are assigned to a computer system.

Step Two: Teacher guide the students on how to download Geometry Pad Software for free

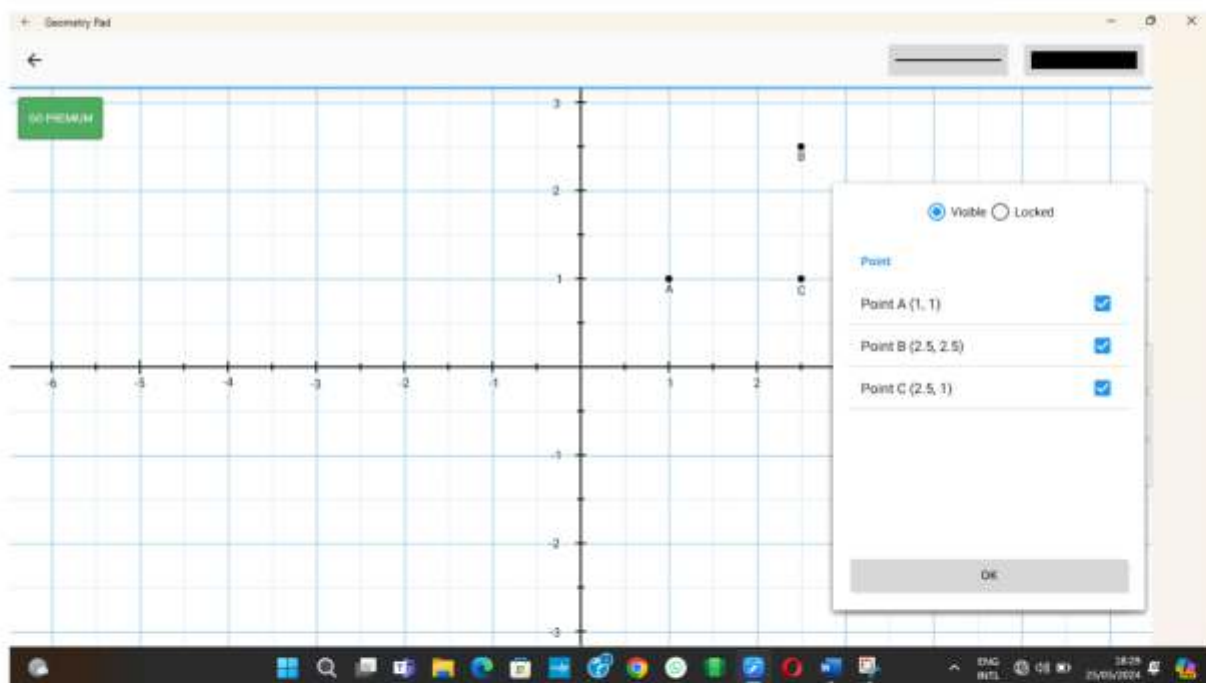
online into their computer system after connecting to the internet.

Step Three: Teacher introduces the Geometry Pad Software and the icons in the software such as Pencil-bar icon for all input, u-bar icon for variable view, Eye-bar icon for displaying output of the result and also points movement, measurement icon, lines, circle, polygon etc.

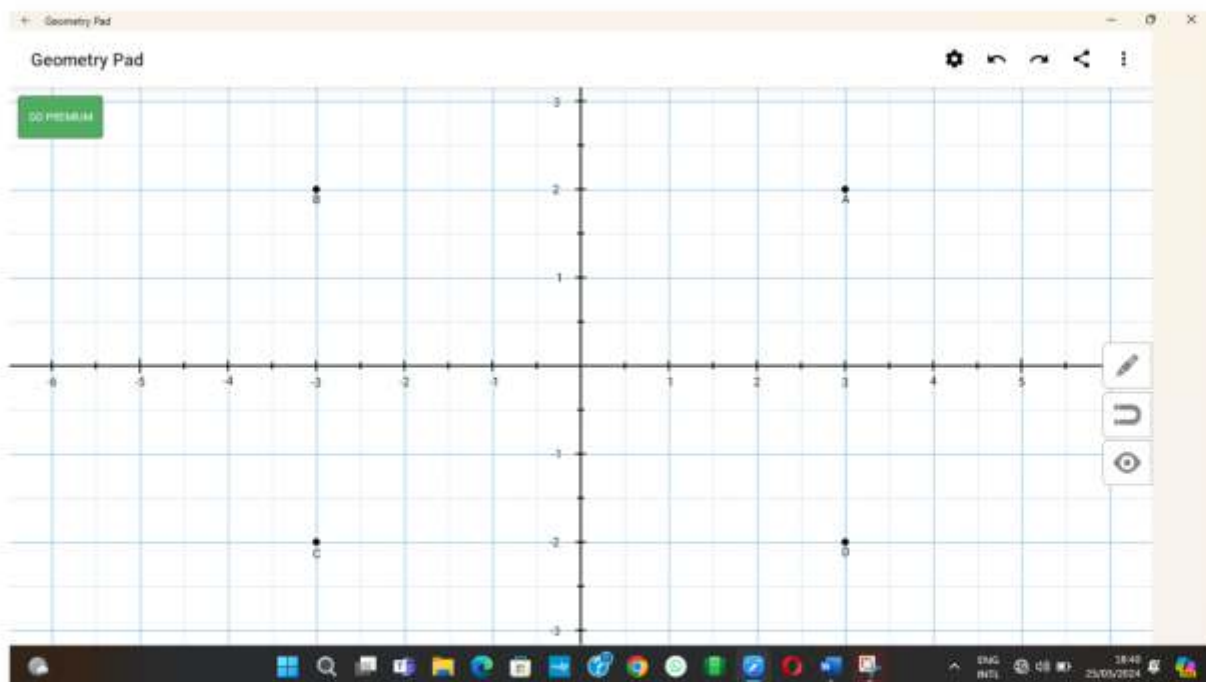




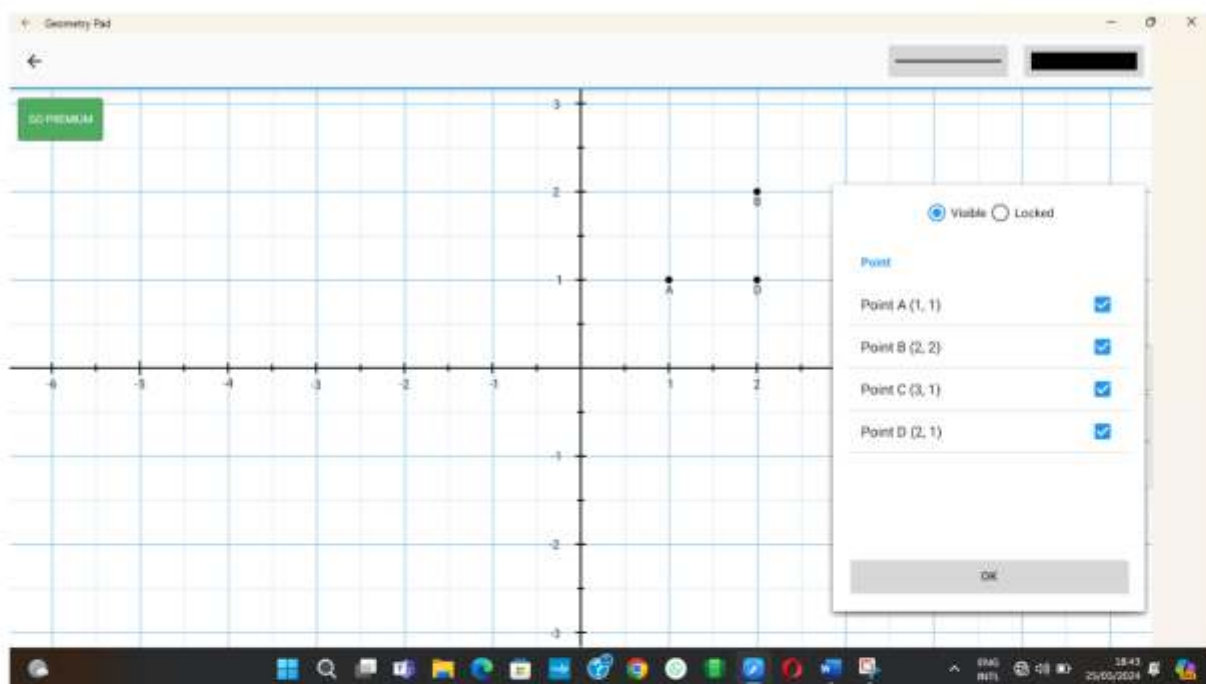
Step Four: Teachers show students the position of result outlet and how it appears in the screen by using eye bar icon for output result of the input as shown below



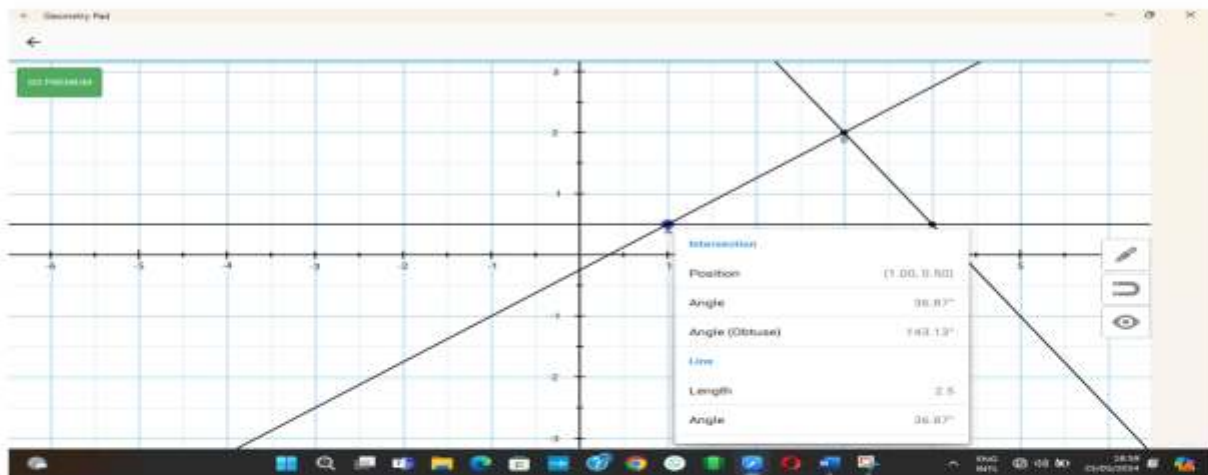
Step Five: Teacher introduces the concept of quadrant on the plane i.e 1st quadrant 2nd quadrant, 3rd quadrant and 4th quadrant, and also shows the values of coordinate of a point on a Cartesian plane. E.g. A (3, 2), B (-3, 2), C (-3, -2), and D (3, -2)



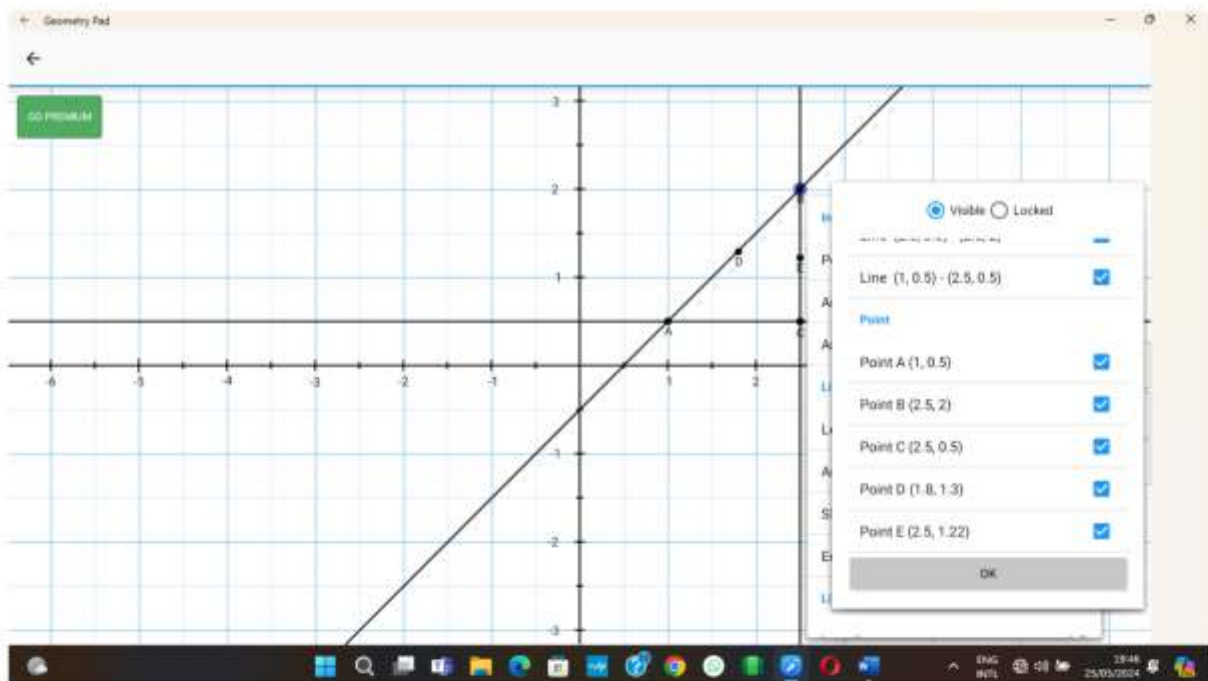
Step Six: The teacher, now move to the next coordinate Geometry topics on location of points on the cartesian plane. Using input bar icon to locate A (1, 1), B (2, 2), C (3, 1), and D (2,1) respectively



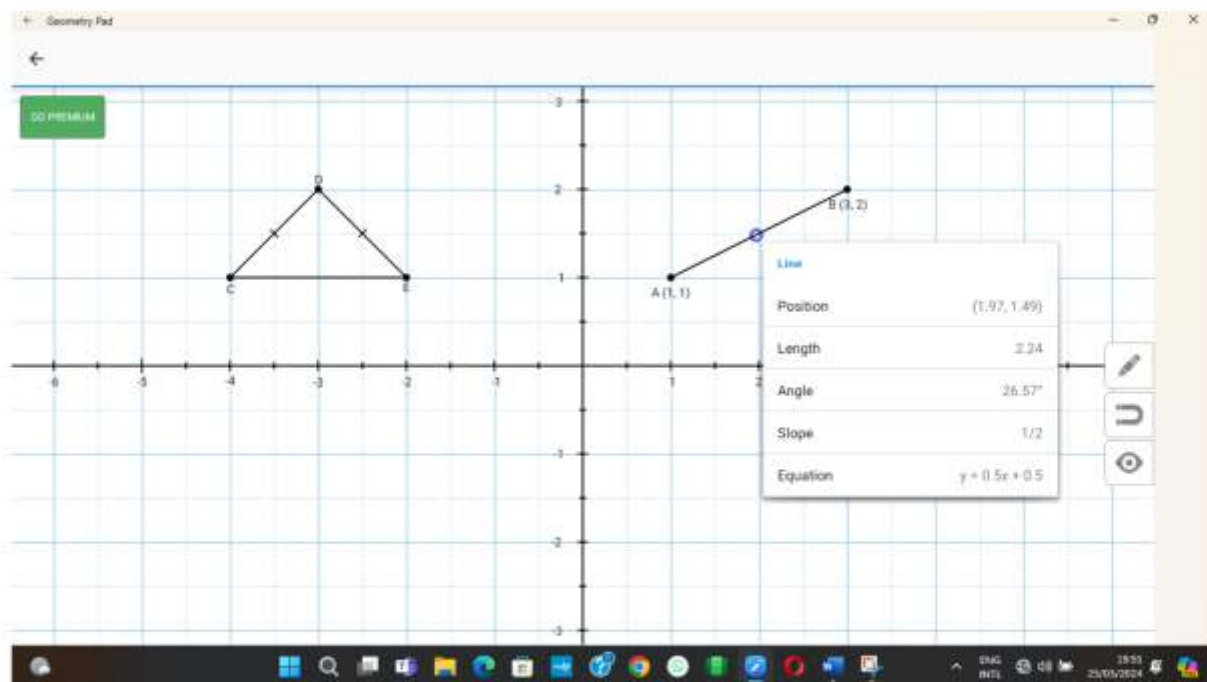
Step Seven: The teacher explains in details on how to calculate distance between two coordinate points on the cartesian plane and locate point A and point B, the distance is between A and B appears automatically in the screen through output icon (eye bar) on the screen of the Geometry Pad layout.



Step Eight: The teacher, introduce in detail by showing how to calculate midpoint value between a line segment of coordinate points A and B using Geometry Pad Software.



Step Nine: Teacher guides the student on how to calculate the slope of given coordinate point using Geometry Pad Software, and show the students the result of the calculation by the left-hand side of the screen.



Results and Discussions

Table 1: Mean and Standard Deviation for Academic Achievement of Experimental and Control Groups.

Groups	N	Mean	S.D	M.D
Experimental	63	28.06	5.22	7.62
Control	47	20.44	5.01	

Table 1 revealed that Experimental group exposed to Hand-Fingers Strategy has ($M = 28.06$, $SD = 5.22$, and $MD = 7.62$) while Control group has ($M = 20.44$, $SD = 5.01$). This indicates that the students exposed to Geometry Pad Software perform higher than those exposed to lecture method.

Table 2: Mean and Standard Deviation for Achievement of Male and Female Students Exposed to Hand-Fingers-Strategy

Groups	N	Mean	S.D	M.D
Male	38	26.72	5.11	0.50
Female	25	27.22	5.43	

Table 2 showed that male exposed to Geometry Pad Software has ($M = 26.72$, $SD = 5.11$, and $MD = 0.50$) while female has ($M = 27.22$, $SD = 5.43$). This indicates that the male and female students exposed to Geometry Pad Software perform equally well.

Table 3: t-test Analysis for Academic Achievement for Experimental and Control groups

Groups	N	Mean	S.Div	df	t	p
Experimental	63	28.06	5.22			
				100	9.453	0.000
Control	47	20.44	5.01			

The result in Table 3 showed that p-value 0.000 is less than the alpha value of 0.05 level of significance at $df = 100$. Since the p-value observed is less than alpha value, it means the difference is significant. Therefore, the null hypothesis one is rejected. The result signifies that Experimental group achieve higher than the Control group.

Table 4: t-test Analysis for Achievement of male and female Students taught using Geometry Pad Software

Gender	N	Mean	S.D	df	t	p
Male	38	25.93	4.29			
				51	-0.783	0.437
Female	25	26.96	5.30			

Table 4: showed that p- value 0.437 is greater than 0.05 level of significance for Male and female students which means that, there is no significant difference in the academic achievement between male and female students taught special angles using Hand-Fingers Strategy. Therefore, the null hypothesis 3 is retained.

Discussions

Based on the results in Table 1 revealed clearly that students who were taught using Geometry Pad Software achieved higher academic achievement than their counterpart students taught with lecture method. This result is in agreement with the finding of Ogbu, et al (2017), Imoko, et al (2016) and Muawiya, (2019) who jointly discover that

students tend to achieve positively when they are taught new mathematics concepts using student-activity method oriented.

Table 2 results indicates clearly that there is no significant difference between male and female in their academic achievement when taught geometry concepts using Geometry Pad Software. The result shows that, both male and female students performed

almost equally same, therefore, this strategy is gender friendly. This finding is in contradiction with Muhammed & Binji (2017), Adams (2021) and Ogbu, et al (2017) who states that male tend to perform higher than female counterpart when exposed to activity-based method of teaching mathematics concepts. The result also in agreement with Muawiya, (2019) and Muhammed, (2023) which states differently that when students are exposed to practical approach, male and female students tend to performed equally in mathematics proficiency.

Conclusions

Based on the findings of this research study, the researcher concludes that the Geometry Pad Software can enhance student's achievement thereby bridging the gap between male and female students if properly utilize. Therefore, use of Geometry Pad Software is an important strategy for better academic achievement in learning and mastering of special angles concepts.

Recommendations

Based on the findings of the study the following recommendations was made such include:

1. Ministry of Education and secondary school board in Nasarawa State should organized works hops for the secondary school Mathematics teachers on Geometry Pad Software for effective teaching and learning of geometry concept.
2. Professional bodies such as Science Teachers Association of Nigeria (STAN), Mathematical Association of Nigeria (MAN) among others, should organize workshops and seminars to popularize and sensitize mathematics teachers on the use of Geometry Pad Software in teaching students the concepts of coordinate geometry.
3. Teacher training institutions of learning should include the use of Geometry Pad Software as a method of teaching geometry concept. This will guarantee that after the teacher training, they will be equipped on how to teach the concepts of geometry effectively.
4. Further research is needed on this strategy to cover larger population in the state and Nigeria at large.

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EFFECTS OF JIGSAW IV COOPERATIVE LEARNING STRATEGY ON STUDENTS' RETENTION IN GEOMETRY AMONG SECONDARY SCHOOL STUDENTS IN ZARIA METROPOLIS, KADUNA STATE, NIGERIA

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Abstract

This study examined the effects of Jigsaw IV Cooperative Learning Strategy (J4CLS) on Students' Retention in Geometry among Secondary School Students in Zaria Metropolis. A pretest, posttest and Post posttest Quasi-experimental research design was used for the study. The experimental group was exposed to J4CLS while the control group was taught using Conventional Method of Teaching. Sample size of students were selected from two Senior Secondary Schools in Zaria Metropolis were used as the study sample, drawn from a population of 15 schools. The two schools selected, were pretested to find their academic status before the treatment. An Instrument was developed named Geometry Performance Test (GPT) with reliability coefficient of 0.79. The Concept of Geometry discussed in this study was plane geometry (2-D Geometry). The data collected were analyzed using Mean scores, Standard deviation and t-test at $\alpha = 0.05$ level of significance. There is significant difference in the mean scores of Secondary students taught Geometry concepts with J4CLS and their counterparts taught with Conventional Method of Teaching in the Metropolis. Students exposed to J4CLS had retained Geometry concepts higher than those taught using Conventional Method of Teaching. Based on the findings, it was recommended among others that, Mathematics teachers should integrate J4CLS into main streams of pedagogy in the teaching at Senior Secondary Schools.

Keywords: Jigsaw IV, Cooperative Learning Strategy, Retention, Geometry and Zaria Metropolis.

Introduction

Mathematics (from Greek word "mathema" knowledge, study, and learning") is the Quantity, Structure, Space and Change. Galileo Galilei (1564-1642) said that the universe cannot be read until we have learnt the language and become familiar with the characters in which it is written. It is written in

Mathematical Language and the letters are Triangles, Circles and other Geometrical Figures, without these, one would be wondering about in a dark muddle. In contemporary Education, Mathematics Education is the practice of teaching and learning Mathematics along with the

associated scholarly research (Tudunkaya, 2019).

Geometry as one of the two fields of pre-modern mathematics, the other being the study of numbers. Geometry from the Ancient Greek; geo "earth", -metro "measurement" arose as the field of knowledge dealing with 2-D and 3-D relationships. Classic geometry was focused on compass and straightedge construction. Geometry was revolutionized by Euclid who introduced mathematical rigor and the axiomatic rigor still in use today. In modern times, geometric concepts have been generalized to a high level of thought and complexity, and have been subjected to the methods of calculus and abstract algebra, so that many modern branches of the field are barely recognizable as the descendants of early geometry. Inekwe (2005) opined that, geometry receives a general disfavor among secondary school students. Numerous studies have shown that geometry is of great important than most areas of Mathematics and also, helps students to understand and love Mathematics (Julie, 2015). Geometry is any shape seen as a set of specific set points, while a plane means a collection of all lines. Pereira, J., Wijaya, T. T, Zhou, Y. & Purnama, A. (2021). Geometry is highly important so much so that, engineers apply its knowledge in construction of houses, cars, chairs and almost all equipment we use in our day to day activities.

The earliest recorded beginnings of geometry can be traced to early populates, who discovered obtuse triangles in the ancient Indus Valley, and ancient Babylonia from around 3000 BC. Early geometry was a collection of empirically discovered principles concerning lengths, angles, areas, and volumes, which were developed to meet some practical need in Surveying, Construction, Astronomy, and Various crafts. Among these were some surprisingly sophisticated principles, and a modern mathematician might be hard put to derive some of them without the use of calculus. For example, both the Egyptians and the Babylonians were aware of versions of the Pythagorean Theorem about 1500 years before Pythagoras and the Indian Sulba Sutras around 800 B.C. contained the first statements of the theorem; the Egyptians had a correct formula for the volume of a frustum of a square pyramid. Adetula (2002), sees it as a tool which helps in logical reasoning with meaningful inference. Adekola (2010), views geometry as the branch of mathematics that deals with the study of shapes both planes and solids. Geometry questions during mathematics examinations were not well attended thus, students do skip geometry questions in the examination (Sambo, 2015). Sambo (2015), stated that, these abilities to make logical reasoning and deductions helps individuals in coining solutions both individual and societal challenges which helps in nation's building.

Geometry is one of the key topics in mathematics which, its knowledge is being applied in many vocations across the globe (Sam & Salman, 2016). It is also, one of the major topics in the senior secondary school mathematics curriculum. The knowledge of geometry is crucial in many fields of human life like Engineering. Geometry helps in logical thinking.

Jig-saw (IV) Cooperative Learning Strategy is based on the theory of Constructivism, Peer learning theory of Piaget (1969) and social learning theory of Vygotsky (1978). The constructivism, is a school of thought that believes in learners actively constructing their own knowledge and understanding using previous knowledge and interacting with instructional materials under the guidance of the teacher. Constructivism is a theory based on observation and scientific study about how people learn (Fosnot, 1996). It says that, people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. When we encounter something new, we have to reconcile with our previous ideas and maybe changing what we believe, or maybe discarding the new information as irrelevant. In any case, learners are active creators of their own knowledge. Constructivist such as Piaget (1977) and Bruner (1996) believe that individuals actively construct their own knowledge by comparing new ideas or

concepts with their current knowledge. In Jigsaw (IV) cooperative learning strategy also, students are actively involved in constructing their own understanding and knowledge of the concepts based on the previous experience acquired and reflecting on those experiences through active participation in the lesson.

The peer learning theory of Piaget, (1969) believed that, learning improved with the help of peers. Piaget found that, children need to discuss their findings as well as having stimulating environment in which they learn in peers. Learners need to be active, have hands-on opportunities, and not to become the least passive as the case may often be. He thought peer interaction could help students to recognize contradictions and interpretation of a problem. The dialogue creates cognitive gains and allowed students have a relationship built on cooperation. Piaget opined that teachers should create an enabling environment of mutual respect such as that of Jig-saw (IV) Cooperative Learning Strategy where learners works in peer and shared the knowledge acquired so as to ensure meaningful learning and mastery of the lesson. The entire group depended on the other member of the group for success. Therefore, this theory supports the use of J4CLS in Science Education.

Vygotsky (1978), in his Social Cognitive Theory, reflected the structure of Jig-saw Cooperative Learning in learners. Vygotsky

believed that infant were born with some level of social-cognitive ability. This ability would have enhanced as long as the children grew-up with understanding and supportive adults who encouraged their verbalization and permitted collaborative conversations. He theorized that, as learners grow, they experience more social interaction with adults and peers. These interactions allow them to develop functions such as language skills, voluntary attention, scientific skills and memory. Vygotsky believed that the zone of proximal development of a child is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under guidance or in collaboration with more capable peers. The zone of Proximal Development is usually determined from below what a child can learn on his/her own, and above by what a child can learn with the help of others, such as peers or teacher as seen in Jig-saw(IV) Cooperative ¹Learning Strategy. This study adopted the theory of constructivism, because students in J4CLS are active creator of their own understanding and knowledge of the concepts given through experiencing things and reflecting on those experiences. Also, in J4CLS introduction is the first step that provides an anchoring idea to understand the tasks given to them at hand.

The Jig-saw is a Cooperative Learning Strategy that is grounded in the belief that learning is most effective when students are actively involved in sharing ideas and work cooperatively to complete their academic task (Gumel, 2015). Jigsaw is a cooperative learning strategy in which everyone becomes an expert and shares learning so that eventually all group members understand the content treated. The Jigsaw model is chosen for the study because of its unique characteristic of providing optimum opportunities for the students to independently study the task given to individual member of the group. This model also makes students to become cream of the crop of their own learning.

The jigsaw technique was created with the goals of enhancing positive educational outcomes and to help students realize they are essential components of a whole and encourages cooperation in a learning environment (Aronson, 2008). In science education, the Jigsaw method is reported to be used in classes more often than other collaborative learning methods, especially in Mathematics, physical sciences and the Earth sciences (Ibrahim, 2019). This is because the Jigsaw method is considered to enhance cooperative learning by making each student stress on a particular topic (Johnson, & Johnson, 2009). This study verified the effect of Jigsaw IV Cooperative Learning Strategy

on Students' Retention in Zaria Metropolis Kaduna State, Nigeria.

Retention however, refers to what is learned minus what has been forgotten (Mang & Mankilik, 2001). Retention as defined by Yero, (2011) is the ability of a learner to recall, remember and recollect a body of Knowledge after passing through instruction. For students' retention, Omar, (2012) observed that students' experience is a significant factor in retention and that the strategies of improving retention rate can be adopted by the teacher. Bichi, (2002) opined that anything which aids meaningful learning improves students' retention and while things that lead to interference among learned materials decrease the speed and efficiency of learning and accelerates forgoing.

Idris, (2014) observed that, retention is the ability to keep and consequently remember things or materials experienced or learned at a later time. Materials to be learned depend on the strategy used in teaching and have an effect to the quality of retention in terms of their meaningfulness, familiarity and image evoking characteristics (Bichi, 2002). Low academic performance as well as retention amongst students in Sciences seems to be as a result of use of teacher's-centered method which lead to poor academic retention, performance and acquisition of requisite skills (Usman, 2000). The Jigsaw model is one of the modern strategies that is students-centered

and enhances meaningful learning through students' interaction in groups of 5-6 to construct their own knowledge, share ideas and complete a given task assigned to them (Gumel, 2010). Studies revealed that, lesson which applied the Jigsaw model was shown to be effective both in cognitive and affective characteristics including meaningful learning, retention; positive learning attitude, interest, self-respect, self-learning ability, confidence, task commitment, sociability, and so on (Yusuf, 2011).

Objectives of the Study

The main objective of this study is to compare the retention ability of students taught 2-D Geometry using J4CLS at Senior Secondary Schools two (SSII) of Zaria Metropolis, Kaduna State, Nigeria.

Research Question

The study addressed this research question.

Is there any difference in the retention ability of students taught 2-D Geometry concept using J4CLS at Senior Secondary Schools two (SSII) of Zaria Metropolis, Kaduna State, Nigeria?

Null hypotheses

Null hypotheses was formulated and tested at $P \leq 0.05$ level of significance.

H₀₁: There is no significant difference in the retention ability of SSII students taught 2-D

Geometry concepts using J4CLS and those taught same concepts using the Conventional Method of Teaching in Zaria Metropolis, Kaduna State, Nigeria.

Research Design

The design for this study is pretest, posttest, and post posttest quasi-experimental research design. This is according to Akuezilo (1993) and Kerlinger and Leer (2005) involves two groups, one group was assigned as experimental and the other group was tagged control. This is suitable because of the advantages listed by (Lakpini, 2006 in Ibrahim, 2019) which is as follows;

- i. The superiority of one instructional strategy over the other can easily be tested
- ii. It gives indications of concept attainment ability of understanding gained by students after they have been exposed to a particular teaching treatment.
- iii. The pretest scores gives indication as to whether the groups are equal in the concepts they hold before interaction was given.

The samples selected were pre-tested to ensure that they are not significantly different. The experimental group was exposed to Geometry concepts for five weeks using J4CLS while the control group was exposed to Geometry concepts also for five weeks using lecture

method. A post test was administered to observe if there was any significant difference in students' academic performance among the groups. A post-post test was administered to both experimental and control group to observe if there was any significant difference in students' retention ability in Geometry concepts.

The population of this study comprises of all public Senior Secondary Schools (SS II) Students in Zaria Metropolis. The random sampling technique was used in order to select the schools in Zaria Metropolis. The instruments for this study is Geometry Performance Test (GPT), were developed for the purpose of generating and analyzing data. The GPT comprises ten (10) items of essay test questions, this is because: Essay test allow students to express their ideas with relatively few restraints. Essay involves recall and write thereby no options to select from, therefore guessing is eliminated. The students must supply answer rather than selecting the good response, thus, it involve descriptive knowledge of students. The posttest in this study is to check the academic performance of the students in SSII on Geometry Concept in Zaria local government. The data collected was used to find the reliability coefficient of the instruments. For the purpose of this study, a test was conducted in order to obtain the data from the preferred School that was pilot tested. The reliability coefficient, was found to

be 0.79. Pre-test was administered to both sampled population groups and the records was kept, then the control group was treated using lecture method of teaching while the experimental group was treated with the Jigsaw IV Cooperative Learning Strategy for five weeks. Then, post-test was administered to both the control and the experimental groups. Later, after sometimes post-post-test

was administered to the groups so as to ascertain the retention ability of the groups. The data collected were analyzed by the application of both descriptive and inferential Statistics. For descriptive Statistics mean and standard deviation was used to describe the research questions while for inferential Statistics t-test was used to answer the null hypotheses at $\alpha=0.05$ (5%) significant level.

Result

Research question: Is there any difference in retention ability on students taught 2-D Geometry with J4CLS and lecture Method of Teaching?

Group	N	Min.	Max.	Mean	Std. Deviation
Experimental	85	12	29	28.10	7.70
Control	72	4	17	13.31	4.74

The results in Table above showed that the students in the experimental group had a mean score of 28.10 retained higher than their counterparts in the control group with a mean score of 13.31 with the difference of 14.79. This shows that **J4CLS** enhances students' retention ability.

H₀₁: There is no significant difference between in the retention ability of Students taught 2-D Geometry concept with J4CLS and those taught with lecture method;

Group	N	Mean	SD	t _{cal}	t _{crit}	Df	Remark
Experimental	85	28.10	7.70	15.78	1.65	155	S
Control	72	13.31	4.74				

Table above shows that the mean scores of post posttest of both the experimental and control groups with the mean of 28.10 and 13.31 respectively. The mean difference between them is 14.79. The hypothesis one says "there is no significant difference in the retention ability of students taught 2-D Geometry concept with J4CLS and that of those taught using conventional method". But from the table above we have $t_{critical} (15.78) > t_{calculated} (1.65)$ at $\alpha=0.05$ significant level. Thus, **H₁** is rejected.

Results

Results of testing null hypothesis shows that significant difference exist in the mean retention abilities of SS II Students taught with J4CLS and those taught with lecture method. The analysis of the hypothesis shows that the use of J4CLS led to higher retention than the traditional lecture method of teaching. The result of the mean scores of the student in the experimental group maintained a higher retention rates than their counterparts in the control group.

The nature of J4CLS is learning by doing and elaborating. In J4CLS, the students worked together in groups, where each student became an 'expert' for a specific topic, and subsequently taught this to his or her home group. This finding agrees with the findings of Sousa, (2006) Tanel & Erol (2008), who found that students in the experimental group taught science concepts with Jigsaw cooperative learning settings had higher retention than those in control group, taught science concepts using traditional method.

Specifically, the finding of Sousa (2006) reports the average percentage of learning material retention after 24 hours when students were taught by different teaching methods. He indicates that there was retention of 50% of material learned in the discussion group, 75% as a result of requests for students to study through practice, and 90% when students teach others in a jigsaw cooperative learning strategy.

An impressive study which lasted for 4 weeks was conducted by Tanel and Erol (2008) in which the effectiveness of the Jigsaw learning method and conventional teaching method were compared on achievement and retention in a Physics course in a University in Turkey. An experimental group received the Jigsaw technique and a control group received traditional lecture teaching.

Conclusion

As a result of the findings in this study, it could be concluded that J4CLS enhances the understanding and retention of 2-D Geometry concepts of secondary school students. This is because all SS II students exposed J4CLS, retained 2-D Geometry concepts better than those exposed to lecture method. J4CLS. This is because when students become active author of their knowledge, analyzed such knowledge and apply it to a real life situation as in J4CLS.

Recommendations

On the basis of the findings and conclusion arising from this study, the following recommendations were made;

1. The use of Jigsaw IV Cooperative Learning Strategy, J4CLS seems to be appropriate in improving the performance and retention ability of students in senior secondary schools 2-D Geometry. It should therefore, be incorporated into the main stream of

pedagogy in the teaching of Mathematics specifically 2-D Geometry and other science subjects at senior secondary schools in Zaria Metropolis, Kaduna State, Nigeria.

2. The use of Conventional Method of Teaching, it has been found in this study, to be relatively ineffective, with respect to retention in the learning of 2-D Geometry concepts. Mathematics

teachers should therefore, exercise cautiousness and expertise in enriching the Conventional Method of Teaching with innovative strategy such as J4CLS so as to avoid situation where under achievement is unwittingly promoted in the course of teaching.

3. In-service training programmes for Mathematics teachers in form of seminars, workshops and conferences.

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EFFECT OF MOBILE APPLICATIONS ON ATTITUDE AND PERFORMANCE OF COLLEGES OF EDUCATION MATHEMATICS STUDENTS IN NORTH-WEST NIGERIA.

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Abstract

The researcher investigated the Effect of Mobile Application on Attitude and Performance of Collages of Education Mathematics Students in North-West Nigeria. The population of the research was 2586 and the sample size was 201NCE II Mathematics students. The researcher used quasi-experimental research design and two colleges of educations were used to be experimental and control group. Six weeks treatment was given to the experimental group on calculus by exposing them on the use of mobile application in solving calculus problems. Differential Calculus Performance Test (DCPT) and Attitudinal Scale on Mobile Application (ASMA) was used as the instruments for the research with reliability index of 0.83 and 0.78. The data collected after the treatment were analyzed using t-test and u-test statistic. The output of the analysis shows that, there is significant different between the attitude' of students that are exposed to use of mobile application for the discussion of Differential Calculus issues and those do not. It is also shows that, there is significant different between the achievement of students that are exposed to use of mobile application for the discussion of Differential Calculus issues and those do not. The researcher concluded that use of Mobile Applications by students in their learning has effect on their attitude and achievement in Differential Calculus among colleges of education in North-West Nigeria. The researcher recommended that lecturers of colleges of education should be exposing their students to the use of mobile applications in making communication, shearing of knowledge and idea to past their learning and improve their attitude.

Key words: Mobile Applications, Attitude, Performance and Differential Calculus

Introduction

The 21st century is a century of science and technology. In this century Information and Communication Technology (ICT) has

become, within a very short time, one of the basic building blocks of modern society (Alabi, Issa and Oyekunle, 2013). Many countries of the world are now regarding and understanding it and mastering its basic skills

and concepts as very crucial in educational system. This is because ICT adds value to the processes of learning and to the organization and administration of learning institutions. It consist of different types of technologies, which are used for collecting, processing and transmitting data and information, using computer facilities. It is an umbrella term that includes communication device or application, including radio, television, cellular phones, computers, network, hardware and software, satellite systems and many more (Alabi, Issa and Oyekunle, 2013). They explained that, ICT focuses specifically on the application of these new technologies in an educational context and environment, and serves as a tool for supporting the various components of education. Such components include, among others, teaching and learning, resources management (human, material, financial resources), admission and examination processes.

Teaching and learning are being migrated to several ubiquitous platforms like mobile application. The World Wide Web has therefore become an indispensable tool in the administration of pedagogy. This development has led to accelerated availability of educational resources and the promotion of collaboration among students within every educational institutions. A significant component of this innovative trend is the adoption of web-based technology in learning.

The use of technology in mathematics education has been highlighted by researchers over the past two decade (Khristin,Keith and Ian, 2018). One of the web-based technology that may be applicable to mathematics students is the mobile applications. Mobile technologies or application have been gaining wider acceptance in education in recent years (Khristin,Keith and Ian, 2018). School and government at their level should introduce these technologies in the classroom so that students can collaborate and shear idea to learning. Potential benefits of using mobile technologies for learning include: facilitating learning across contexts, facilitating contextual learning, and providing personalization in both personal and collaborative environments (Cochrane 2010). These potentials make mobile technology seem an ideal tool for learning mathematics.

Mobile applications have provided various approaches to learning such as engaging students in contextualized learning environments using mobile phone, getting accesses to materials on line, connecting learners through mobile phone and social media. Students explained that the activities using mobile application made them recall the topics better and helped them visualize the concepts being learned as was the case in other mobile learning studies (Spikol and Eliasson 2010). However, videos, animations and math manipulates are typical mediums

that are used to help visualize mathematics concepts both in mobile learning environments and computer-based environments. However, with mobile application, an additional medium for visualization is the learners' environment, facilitating a connection between the abstract mathematics concepts to real. Some students felt that this new way of learning mathematics had helped them grasp abstract mathematics concepts and as a result helped them remember better. These explanations were supported by Crompton and Burke's (2015) that mobile learning in mathematics showed that there is a growing attitude in mobile technology effectiveness, with 75% of 48 respondents reporting positive learning outcomes. Similarly, in Fabian (2016) review of mobile learning studies in mathematics, 77% of 31 respondents reported that mobile technologies improved students' achievement. But there are more reports of successful mobile learning studies in mathematics such as study conducted by Norries, Hossain, and Soloway (2011) in their study demonstrated that students' achievement increase significantly when using mobile learning devices during learning time. This is because they limitless time in using the application to carry out any activities given to them. Norries et al. (2011) also found that students were constantly using the smartphone camera to take pictures of abstract concepts taught in class so that later they could relate them with the concrete ideas. Mobile application can be

used to communicate any mathematical problems, which become difficult to students. The problems can either sent in pictures form or in message to the groups or individual to interact and shear idea to find the solution of the problems. Similarly, Woodcock (2012) reported that respondents in their research believed that smartphones had allowed them to improve productivity and eventually their learning performance. Kumar (2011) indicated that students were downloading online lectures note, journal, magazines, and reading from e-books to improve their attitude and the learning out comes in mathematics. Another study conducted by Mtega, Bernard, Msungu, and Sanare (2012), shows the respondents in their study do not just use traditional mobile learning applications, such as text messages and calls, but they utilize mobile learning applications such as GPS, camera, voice calls, emails, Google drive, and so on and so forth, to create, upload, download and share mathematics resources with their friends. All the above reviewed research illustrated that mobile applications have created important avenues for students to learn through collaboration and it is undeniable that more students are spending more time using mobile applications to solve mathematical problems. It is clearly seen that none discussed the differences between the achievement and attitude of those that used mobile applications for mathematical issues and those that do not and also the gender differences between the

users which the present study is trying to finding out.

Empirically, the researcher reviewed recent works that are relevant to the present research, such as the work of Siew, Nor, Nor and Nur (2017), investigate the relationship between smartphone use and academic performance of students in Malaysian tertiary institution. They used correlational research design to determine the relationship between the used of smartphone and the students' performance. The population of the study was 412 students and a sample of 180 students. A questionnaire was used to collect data on the use of smartphone and the reliability of the instrument was 0.81. The data collected was analyzed using descriptive analyses. The result indicated that, there is significant weak inverse relationship between the used of smartphone and students performance.

Another study conducted by Jonathan and Leocineza (2018) on the effect of mobile application in teaching high school mathematics in Philippine. The researchers used the quasi-experimental method of research using the pretest-posttest design. It used two groups of subjects with 40 students per group. The students were enrolled in Grade 8 mathematics. Frequencies, simple percentage, mean, standard deviation, rank, and t-test were used to treat the gathered data. The study revealed that there is an increase in the posttest scores of the control and

experimental groups. It was concluded that the use of the mobile application in teaching mathematics to Grade 8 students had helped enhance students' achievement and learning. The researchers recommend that the proposed action plan be used and monitored to help students in mathematics.

Study conducted by Khristin, Keith and Ian (2019) investigated the used of mobile technologies for mathematics: effects on student attitudes and achievement. A quasi-experimental mixed method design was adopted. Participants were 52 Primary 6 and 7 students. The experimental group have positive perception of the activities evidenced by student interviews and end activity evaluations. Students' attitude to mathematics, as assessed by a mathematics attitude inventory, found no significant change for both groups except for the significant decline in enjoyment for the control group. A t-test of the gain score between group showed a significant difference, $t(43) = 4.57$, $p = 0.005$ which indicates that the experimental group had higher gains than the control group. These results indicate that the use of mobile technologies elicit positive responses from students both in terms of how they perceive the mobile activities and how it improved their performance but its' effect on students attitudes towards mathematics will need to be further investigated. Some implications of the findings are discussed.

Moyazzem (2019) conducted a research on Impact of Mobile Phone Usage on Academic Performance of university students in Bangladesh. A face to face survey was conducted among 274 students which include 159 male students and 115 female students ranging from second year to fourth year from different departments of Jahangirnagar University, Bangladesh. Results depicts that gender, age and relationship with opposite sex have the significant positive effect on students' academic performance. However, marital status, spending time on mobile phone, negative effect of mobile phone and application usage while studying has the negative effect on students' academic performance. Cell phones are undeniably convenient, helpful tools for study and can be a hurtful source of distraction depending on the attitude and use pattern of a student. The author, however, suggests that the mobile phone designers must take into account how young people use cell phones for educational purposes. Base on the empirical study none of the study was conducted in colleges of education in particular in north-west Nigeria. Also none of study that use descriptive survey design and expo-factor to determine the opinion and achievement in mathematics of respondents that use mobile applications for mathematical issues these that do not.

Objectives of the Study

The following objectives were raised to: examine the differences between the attitude of students that are expose to the use of mobile application on the discussion of Differential Calculus issues and those that do not.

1. find out the differences between the attitude of male and female students that are expose to the use of mobile application on the discussion of Differential Calculus issues.
2. determine the differences between the performance of students that are expose to the use of mobile application on the discussion of Differential Calculus issues and those that do not.
3. investigate the differences between the performance of male and female students that are expose to the use of mobile application on the discussion of Differential Calculus issues

Null Hypothesis:

The following null hypothesis were raised to be tested at $p \leq 0.05$ level of significance

H₀₁ : There is no significant different between the attitude of students that are exposed to use of mobile application for the discussion of Differential Calculus issues and those do not.

H₀₂: There is no significant different between the attitude of male and female students that are exposed to the use of mobile

application for the discussion of Differential Calculus issues.

H0₃: There is no significant difference between the performance of students exposed to the use of mobile application on the discussion of Differential Calculus issues and those do not.

H0₄: There is no significant difference between the performance of male and female students exposed to the use of mobile application on the discussion of Differential Calculus issues.

Methodology:

The researcher adopted quantitative method involving quasi-experimental design. This kind of design is appropriate for this study because the researcher intends to find out the effect of mobile applications on attitude and performance in differential calculus. The population of this study comprises all colleges of education mathematics students in north-west Nigeria. The total population of the mathematics students are 2,589. It is involve NCEII (2) mathematics students. In north-west Nigeria there fifteen (15) colleges of education out which seven (7) are federal colleges education while the remaining eight (8) are state colleges of education.

The sample size of this study is 201 mathematics students. The sample size was drawn using stratified sampling techniques,

the researcher stratified the college of education in two that is, state and federal college of education. A simple random sampling techniques involving balloting was used to sample two colleges of education from the two strata. The students of one of the two colleges of education was exposed to the use of mobile application in learning differential calculus while the other college are not. That is to say one college consider as experimental group while the other is control group.

The instruments used for the purpose of data collection was a Differential Calculus Performance Test (DCPT) and Attitudinal Scale on Mobile Application (ASMA). The DCPT consist of two section A consist of students bio data and the section consist of fifty objectives questions with four options (A-D). ASMA consisted of two sections, section A consist of students or respondents bio-data and section two consisted of twenty items of the students' attitude toward use of mobile application to solve Differential Calculus problems. The items was set inform likert-scale of strongly agree (SA), Agree (A), strongly Disagree (SA) and Disagree (D). The instrument was validate by experts and pilot tested in college that are within the population but not in the sample. The data collected from the pilot testing was used to determine the reliability coefficient of the instrument. The reliability coefficient was obtained using Cronbach's alpha test. The result revealed

that, the reliability coefficient of DCPT is 0.83 and for ASMA is 0.78.

The research was conducted during the second semester of 2019/2020 academic session. The researcher give six weeks treatment to the experimental group. After the treatment a post-test was given to both experimental and control groups. The script and the questionnaire were collected and mark by the researcher. The data obtained for the performance and the attitude were analyze using t-test and Mann-Whitney (U-test) Statistic. The null hypothesis one and two were tested using U-test because the data collected was a nominal data and two groups

are comparing. The null hypothesis three and four were tested using t-test because, the data collected was an interval data and two groups were comparing. The data collected was used to test the null hypothesis. The summary of the test analysis of the null hypothesis are presented in tables as follow.

H₀₁: There is no significant different between the attitude of students that are exposed to use of mobile applications for the discussion of Differential Calculus issues.

To test the null hypothesis, Mann-Whitney test was used. The summary of the test analysis in shown in table one (1):

Table 1: Summary of Mann-Whitney test analysis of student's attitude expose to use of mobile applications for the Discussion of Differential Calculus issues.

Groups	N	Mean rank	Sum of rank	χ^2_{cal}	Df	P-value	Decision
Experimental	95	74.89	41275.00				
				6.88	199	0.00	Rejected
Control	106	68.81	27923.00				
Significant at P< 0.05 level							

Table 1: revealed that analysis of Mann-Whitney test with χ^2_{cal} values in 6.88 and p-value of 0.00 at df of 199. The p-value is $0.00 < 0.05$. Therefore, we rejected the null hypothesis and conclude that, there is significant difference between the attitudes of students that are exposed to the use mobile applications for learning of differential calculus. This show that, use of mobile applications has positive effect on the student's attitude that used mobile applications on learning of differential calculus.

H0₂: There is no significant different between the attitude of male and female students that are exposed to the use of mobile applications for the discussion of differential calculus issues. To test the null hypothesis Mann-Whitney test was used. The summary of the test analysis in shown in table two (2):

Table 2: Summary of Mann-Whitney test analysis of male and female student's attitude expose to the use of mobile applications for the Discussion of Differential Calculus issues

Groups	N	Mean rank	Sum of rank	χ^2_{cal}	df	P-value	Decision
Male	65	57.89	112.00	3.10	93	0.01	Rejected
Female	30	18.81	592.00				

Significant at 0.05 level

Table 2: shows the summary of analysis of Mann-Whitney test with χ^2_{cal} values in 3.10 and p-value of 0.01 at df of 93. The p-value is $0.01 < 0.05$. Therefore, we rejected the null hypothesis and conclude that, there is significant different between the attitude of male and students that are expose to the use of mobile applications for the discussion of differential calculus issues in favour of male. This show that, use of mobile application has positive effect on the male student's attitude toward differential calculus than the female.

H0₃: There is no significant different between the performance of students that are exposed to the use of mobile applications on the discussion of differential calculus issues and those that do not.

Data on student's performance that use mobile applications on the discussion of differential calculus issues and those that do not were collected. To test the null hypothesis t-test statistic was used. The summary of the analysis in shown in table 3.

Table 3: Summary of t-test of student's performance that used mobile applications on the Discussion of Differential Calculus and those that do not.

Groups	N	Mean	Std. deviation	df	t_{cal}	P-value	Decision
Experimental	95	75.74	54.87	199	2.42	0.01	Rejected

Control	106	37.32	22.34
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Significant at 0.05 level

Table 2 shows that, the calculate value of t is 2.07, and p -value of 0.01 at df of 199 is less than the alpha value of 0.05. Based on this evidence the null hypothesis is rejected. This implies that, there is significant difference between the performance of students that are exposed to use of mobile applications for the discussion of differential calculus and those that do not. The result indicated that students that used mobile application for the discussion of differential calculus performed better than, those that do not. Therefore, the use of mobile applications has significant effect on the students' performance in differential calculus.

H₀₄: There is no significant difference between the performance of male and female students that exposed to the use of mobile applications for the discussion of differential calculus issues. Data on male and female student's performance that used mobile applications for the discussion of differential calculus issues were collected. To test the null hypothesis t -test was used. The summary of the analysis is shown in table 4:

Table 4: Summary of t -test of male and female student's performance that are exposed to the use of mobile applications for the discussion of differential calculus issues.

Groups	N	Mean	Std. deviation	df	t_{cal}	P-value	Decision
Male	65	58.97	42.87	93	2.07	0.01	Rejected
Female	30	20.52	13.34				

Significant at 0.05 level

Table 4 shows that, the calculate value of t is 2.07, and p -value of 0.01 at df of 93 is less than the alpha value of 0.05. Based on this result the null hypothesis is rejected. This implies that, there is significant difference between the performance of male and female students that are exposed to the use of mobile applications for mathematical issues. The result indicated that male students that used mobile application for the discussion of differential calculus issues performed better than female students. Therefore, the use of mobile applications has significant effect on male students' performance in differential calculus than the female students.

Discussion

The present study investigated the effect of mobile applications on attitude and performance of colleges of education mathematics students in Nigeria. The null hypothesis formulated to guide the researcher were tested using the data collected. The results of test were presented in tables. Table 1 revealed that, there is significant difference between the attitude of students that are exposed to the use of mobile applications for the discussion of differential calculus issues and those that do not. This finding is not in line with the findings of Miller and Robert sons (2010) that, use of mobile learning did not result to a change in attitude towards mathematics. The variation in the result may be because the students are now much more familiar with use of mobile applications in doing all their activities either academic or social. Colleges of education students that use mobile applications for their discussion of differential calculus issues developed more positive attitude than, those that do not, because they are using the application to collaborate, associate and sharing of idea in a large group outside the class.

Table 2 revealed that, there is significant difference between the attitude of male and female students that are exposed to the use of mobile applications for the discussion of differential calculus issues. The finding of this study is in contrast with the finding of Khritin,

Keith and Ian (2018), who found that, there is no significance difference between the attitude of male and female students exposed to the use of mobile application for the discussion of differential calculus. May be the reasons why the result are differed is that, the research was conducted in different location, which may lead to have difference in the orientation on how to use mobile applications in the academics discussion.

Table 3 revealed that, there is significant difference between the performance of students that are exposed to the use of mobile applications for the discussion of differential calculus issues and those that do not. This finding is in line with the finding of Md. Moyazzenun (2019) who found that mobile phone applications are improving academic performance of students in mathematics. Mobile application is serving as a learning strategy that support the teaching strategy used by the lecturers in the college. Learning through collaboration and shearing of ideas is more permanent than learning in the classroom because it's not all students can participate in the class, because of one or two reason that are personal to him. These using mobile applications can discuss issues that has to with learning of differential calculus.

Table 4 revealed that, there is significant difference between the performance of male and female students that are exposed to the use of mobile applications for the discussion of

differential calculus issues and those that do not. This finding is not in line with the finding of Md. Moyazzenun (2019) who found that use of mobile phone applications is gender friendly in term of students' academic performance in mathematics.

Conclusions:

The study concludes that the use of mobile applications in learning differential calculus among public colleges of education in north-west, Nigeria significant has effect on the student's attitude and achievement in mathematics. Those that used mobile applications for differential calculus help to developed positive attitude and performed higher in differential calculus than those that do not

Recommendation

Based on the result of the findings, the researcher recommends that:

- The stakeholder of college of education in north-west, Nigeria should provide a powerful internet services within the college to enable the students get connected with each other for their mathematical discussion in other to improve their mathematical performance.
- Sensitization orientation or workshop should be organized for the students, to have knowledge on how to use mobile application to solve mathematical problems and reduce the negative attitude toward learning of mathematics.
- Lecturers of collages of education should be exposing their students to the use of mobile applications in making communication, shearing of knowledge and idea to past their learning and improve their attitude.

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INVESTIGATING OF DIFFICULT TOPICS ENCOUNTERED BY SECONDARY SCHOOL MATHEMATICS TEACHERS IN LERE EDUCATIONAL ZONE, KADUNA STATE, NIGERIA

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Abstract

This study investigates the difficult topics encountered by secondary school mathematics teachers in Lere Education Zone, Kaduna State, Nigeria. The weak and erroneous foundation students often receive at the secondary school stage, resulting from the difficulties teachers face in teaching some selected topics, has become a major challenge to all stakeholders in education. A descriptive survey research design was adopted, and data were collected using a self-developed questionnaire administered to junior secondary school mathematics teachers (JSSMCTQ) and senior secondary school mathematics teachers (SSSMCTQ). The instruments, with reliability indices of 0.63 and 0.71 respectively using Cronbach's alpha, were validated by three experts: two from the Department of Science Education, Ahmadu Bello University, Zaria, and one from the Department of Mathematics, Federal University of Education, Zaria. Two research questions and two null hypotheses were formulated to guide the study. A sample of eighteen teachers was selected from a population of thirty-four. Data were analyzed using frequency counts and simple percentages. Findings revealed no significant variation in the secondary school mathematics curriculum areas where teachers encounter difficulties. However, it was discovered that some mathematics topics are considered difficult to teach, requiring refresher training before teachers can effectively deliver them. Based on the findings, it was recommended that Re-fresher training in the form of workshops and seminar should be regularly organized by the ministry of education for Mathematics teachers in order to improve their competence in teaching difficult topics. Based on the findings, it was recommended that refresher training in the form of workshops and seminars should be regularly organized by the Ministry of Education for mathematics teachers to improve their competence in teaching difficult topics.

Keywords: Difficult topics, Mathematics teachers, Lere Educational zone

Introduction

A good and proper knowledge of mathematics is widely accepted to be the basis upon which the nation builds its scientific and technological growth and development. Mathematics is seen by the society as the

foundation of scientific and technological knowledge, which is vital in the socio-economic development of a nation. Mathematics education is generally accepted as the foundation for science and technology (Maass et al., 2019). Thus, understanding and

performance of mathematics has become a matter of concern to all stakeholders in education. It is an extensive field that has been variously defined from different perspectives. It is the language of used to express logical ideas, shapes quantities, size, order, change, and dynamics in the system, and to explain the complexities of modern society in business, economic, academic, engineering, and medical settings (Abdurrahman & Bolaji, 2018). It is the science of size and numbers, logical reasoning, and model thinking that constitutes everyday activities (Mutege et al., 2021). It is a creation of human mind, concerned primarily with ideas, processes and reasoning. However, all these definitions converged to the same meaning hence, mathematics means the study of numbers, shapes equality, inequality, symbols, measurement, relationship and so on (Aminu, 2014). It is therefore not suppressing that mathematics is one of the core subjects taking note of a country's quest for rapid technological and scientific development (NPE, 2013). For this reason, the knowledge of the subject cannot be overemphasized.

A number of studies have reported the downward trend in the performance of Nigerian students in science at the senior secondary certificate examination (SSCE) among them mathematics is one (Ajagun, 2001). This rate of failure at SSCE has continued to be a matter of concern to all stakeholders in education. A lot of reasons have been identified to be responsible for the high

rate of failure, prominent among them are; teachers' use of inappropriate methods of teaching, overloaded mathematics syllabus, difficulty of topics and some concepts as well as absence of dedication and resourcefulness on the part of the teachers as identified by (Lawal, 2010). This is so because teachers are regarded as the major factor in implementing the educational objectives and policies and as such should be recognized because when something goes wrong within the educational system, the teachers are first to be blamed (Koko & Nwiyi, 2007)

In response to the on-going global reform in the educational and technological development of our society, teachers are expected to be the best minds of any country and mathematics should be the basic tool to achieve this national goals. Research evidences has shown that, the single most influential factor in students' performance in all the subjects is the teacher. That is why the Federal Republic of Nigeria in the National Policy on Education (Federal Ministry of Education, FME. 2013) also recognized the importance of teachers by stating that "no nations' education system can rise above the qualities of its teachers". Therefore, teachers remain the major factor in any educational system and their quality of teaching is undoubtedly one of the most important factors shaping the teaching/learning and achievement of students (Fenstermacher & Richardson, 2005). The chief examiner's reports of the

West African Examination Council WAEC commented that “the performance of candidates in the examination justify that the schools with experienced teachers continues to monopolize good performance” (WAEC, 2000).

Statement of the Problem

It is generally believed that mathematics played a vital role in scientific and technological development of the nation. Upon all the importance, its teaching and learning are faced with some problems which makes most students to perform poorly in the subject. This might have resulted from weak and erroneous foundation they receive at early stage as a result of difficulties faced by the teachers in some selected topics which made them to teach the topics poorly, wrongly, partially, skip or even ignore the topics. This observation became a challenge to all the stake holders in education and hence the search for the difficult topics encountered by the secondary school teachers became necessary and this is why the current effort is being raised to sort out the topics so as to find a way of eradicating or reducing them to the barest minimum. Therefore, the need to investigate the difficult topics encountered by mathematics teachers in Lere Local Government Education Zone of Kaduna State, Nigeria cannot be over emphasized.

Objectives of the Study

The purpose of this study was to investigate the “Difficult Topics Encountered by Mathematics Teachers in Lere Local Government Education Zone of Kaduna State, Nigeria”. The study aimed to determine the area of difficulties in the Secondary School Mathematics Curriculum. Specifically, the study aimed to;

1. Discover areas in the secondary school mathematics curriculum that mathematics teachers find difficult to teach.
2. Find out areas in the secondary school mathematics curriculum where mathematics teachers require further training before they can adequately teach the topics.
- 3.

Research Questions

The following research questions were raised to guide the conduct of the study:

1. Are there significant areas in the secondary school mathematics curriculum that mathematics teachers find difficult to teach?
2. Are there significant areas in the secondary school mathematics curriculum where mathematics teachers require further training before they can adequately teach the topics?

Null Hypotheses

The following null hypotheses were formulated to guide the study;

Ho₁: There are no significant areas in the secondary school mathematics curriculum that mathematics teachers find difficult to teach.

Ho₂: There are no significant areas in the secondary school mathematics curriculum where mathematics teachers require further training before they can adequately teach the topics.

Methodology

This study investigated the “Difficult Topics Encountered by Mathematics Teachers in Lere Local Government Education Zone of Kaduna State, Nigeria”. The research design used for this study was a descriptive survey. The population of this study comprises of the thirty-four (34) teachers from the thirty-four secondary schools in Lere local government education zone, among them eleven (11) teachers teach at junior secondary section while twenty-three (23) teachers teach at senior secondary section. Out of them thirty (30) teachers are Males and four (4) teachers are Females.

The sample of this study consist of eighteen (18) teachers, among them, six (6) teachers teach at junior secondary section while twelve (12) teachers teach at senior secondary section. her sample were selected using multy-stage and purposive sampling techniques.

These samples were based on the available returned questionnaires.

A questionnaire named; mathematics concept teachers’ questionnaire (MCTQ) of two types; Junior Secondary School Mathematics Teachers’ questionnaire (JSSMTQ) with thirty-three (33) items drawn from Junior Secondary School Mathematics Curriculum and Senior Secondary School Mathematics Teachers questionnaire (SSSMTQ) with forty (40) items drawn from Senior Secondary School Mathematics Curriculum was used for data collection. These instruments consisted of all the topic involved in the junior and senior secondary mathematics curriculum respectively where instructions were given to the teacher to identify the topic in which they are having difficulty or order wise arranged in a Likert – scale form as; very competence, quit competence, competence, not quit competence, very necessary and not quite necessary.

The instruments were validated by three experts on the rank of senior lecturer and above, two from Department of Science Education A.B.U, Zaria and one from Department of Mathematics, Federal University of Education, Zaria. Their corrections were noted and incorporated. The reliability of the instruments was tested using test, re-test reliability using Cronbach’s alpha in order to establish the internal consistency of the items and the Cronbach’s alpha reliability

coefficient was found to be 0.63 and 0.71 for the JSSMTQ and SSSMTQ respectively.

The administration and collection of the questionnaire was done by the researcher with the help of the zonal director and heads of the schools. Questionnaires were distributed and collected latter through the principals of the schools. Ten (10) questionnaires were distributed for junior secondary mathematics teachers and six (6) were returned and twenty-five (25) questionnaires were distributed for senior secondary mathematics teachers while twelve (12) were returned. This gives the total of eighteen (18) returned questionnaires for both Junior and Senior Secondary sections which were sorted based on identical opinions of the respondents for easy tabulation. In analyzing the questionnaires, the researcher made very competence and quit competence as quit competence, competence and not quit competence as not quit competence, very necessary and not quite necessary as not quite necessary.

For analyzing hypotheses, the raw data collected through the method of research instrument was processed and prepared for presentation as tabulated evidences. The technique used in constructing these tables include; frequency and percentage calculations. Thus, all the conclusions about the findings of this study were made on the bases of percentage of the responses recorded. The tables were prepared to serve as the main frame-work around which the analyses, conclusions and recommendations were made.

Result

Based on the findings, the following results were made:

H_{01} : There are no significant areas in the secondary school mathematics curriculum that mathematics teachers find difficult to teach.

Table 1: Number and percentage of teachers having difficulty in teaching some selected topics for Junior Secondary School teachers.

Items	Not Very Competence (NVC)	Percentage of Not Very Competence	Not Quit Competence, (NQC)	Percentage of Not Quit Competence,	Quit Competence, (QC)	Percentage Quit Competence,
1.	1	16.7	2	33.3	3	50.0
2.	1	16.7	3	50.0	2	33.3
3.	1	16.7	2	33.3	3	50.0
4.	-	-	4	66.7	2	33.3
5.	-	-	3	50.0	3	50.0
6.	2	33.3	1	16.7	3	50.0
7.	2	33.3	2	33.3	3	50.0
8.	1	16.7	2	33.3	3	50.0
9.	1	16.7	2	33.3	3	50.0
10	-	-	2	33.3	4	66.7
11	2	33.3	1	16.7	4	66.7
12	1	16.7	2	33.3	3	50.0
13	2	33.3	2	33.3	3	50.0
14	1	16.7	2	33.3	3	50.0
15	1	16.7	1	16.7	4	66.7
16	-	-	2	33.3	4	66.7
17	1	16.7	2	33.3	3	50.0
18	-	-	3	50.0	3	50.0
19	1	16.7	2	33.3	3	50.0
20	2	33.3	-	-	4	66.7
21	1	16.7	1	16.7	4	66.7
22	-	-	4	66.7	2	33.3
23	2	33.3	1	16.7	4	66.7
24	3	50.0	1	16.7	3	50.0
25	2	33.3	1	16.7	3	50.0
26	-	-	2	33.3	4	66.7
27	-	-	2	33.3	4	66.7
28	-	-	3	50.0	3	50.0
29	1	16.7	1	16.7	4	66.7
30	1	16.7	1	16.7	4	66.7
31	1	16.7	1	16.7	4	66.7
32	-	-	3	50.0	3	50.0
33	2	33.3	1	16.7	4	66.7

Table 1 reveals that eight (8) out of thirty-three (33) items have at least 50% of the total topics where the teachers rate themselves as not very competence and of not quit competence to teach. This implies that there are about 24% (8 out of 33) of the total topics where teachers are having difficulty in teaching the topics. These topics are; Modular arithmetic, Sets, Simple equation and

variations, Gradient of a curve, Circle theorem, Bearing, Cumulative frequency graph and Application of linear and quadratic to capital market.

Table 2: Number and percentages of teachers having difficulty in teaching some selected topics for Senior Secondary school teachers.

Items	Not Competence (NVC)	Very Percentage of Not Very Competence	Not Quit Competence, (NQC)	Percentage of Not Quit Competence,	Quit Competence , (QC)	Percentage Quit Competence,
1.	1	05.9	3	17.6	13	76.5
2.	5	29.4	5	29.4	7	41.2
3.	1	05.9	1	05.9	15	88.2
4.	1	05.9	2	11.8	14	82.4
5.	-	-	2	11.8	15	88.2
6.	-	-	4	23.5	13	76.5
7.	3	17.6	9	52.9	5	29.4
8.	5	29.4	8	47.1	4	23.5
9.	5	29.4	5	23.5	7	41.2
10	2	11.8	5	29.4	9	52.9
11	-	-	4	23.5	13	76.5
12	-	-	2	11.8	15	88.2
13	-	-	1	05.9	16	94.1
14	1	05.9	2	11.8	14	82.4
15	1	05.9	6	35.3	11	64.7
16	1	05.9	3	17.6	13	76.5
17	1	05.9	2	11.8	14	82.4
18	3	17.6	4	23.5	10	58.8
19	-	-	5	29.4	12	70.6
20	1	05.9	3	17.6	13	76.5
21	4	23.5	5	29.4	8	47.1
22	4	23.5	4	23.5	9	52.9
23	2	11.8	6	35.3	9	52.9
24	3	17.6	4	23.5	10	58.8
25	2	11.8	2	11.8	13	76.5
26	2	11.8	1	05.9	14	82.4
27	2	11.8	2	11.8	13	76.5
28	2	11.8	3	11.8	12	70.6
29	-	-	7	41.2	10	58.8
30	1	05.9	4	23.5	12	70.6
31	5	29.4	7	41.2	5	29.4
32	6	35.3	5	29.4	6	35.3
33	2	11.8	6	35.3	9	52.9
34	-	-	7	41.2	10	58.8

35	3	17.6	7	41.2	7	41.2
36	4	23.5	3	17.6	10	58.8
37	2	05.9	2	11.8	13	76.5
38	-	-	6	35.3	11	64.7
39	1	05.9	8	47.1	8	47.1
40	1	05.9	7	41.2	9	52.9

Table 2 reveals that only one (1) out of forty (40) items have at least 50% of the total topics where the teachers rate themselves having difficulty to teach the topic. This implies that there is about 2.5% (1 out of 40) of the total topics where teachers are having difficulty in teaching the topics. This topic is; Logical reasoning.

Ho₂: There are no significant areas in the secondary school mathematics curriculum where mathematics teachers require further training before they can adequately teach the topics.

Table 3: Number and percentage of teachers who require further training on some selected topics for junior secondary school teachers.

Items	Very Necessary (VN)	Percentage of Necessary	Not Quite Necessary (NQN)	Percentage of Not Quite Necessary	Not Required (NR)	Percentage of Not required
1.	1	16.7	2	33.3	3	50.0
2.	1	16.7	3	50.0	2	33.3
3.	1	16.7	2	33.3	3	50.0
4.	-	-	4	66.7	2	33.3
5.	-	-	3	50.0	3	50.0
6.	2	33.3	1	16.7	3	50.0
7.	2	33.3	2	33.3	3	50.0
8.	1	16.7	2	33.3	3	50.0
9.	1	16.7	2	33.3	3	50.0
10	-	-	2	33.3	4	66.7
11	2	33.3	1	16.7	4	66.7
12	1	16.7	2	33.3	3	50.0
13	2	33.3	2	33.3	3	50.0
14	1	16.7	2	33.3	3	50.0
15	1	16.7	1	16.7	4	66.7
16	-	-	2	33.3	4	66.7
17	1	16.7	2	33.3	3	50.0
18	-	-	3	50.0	3	50.0
19	1	16.7	2	33.3	3	50.0
20	2	33.3	-	-	4	66.7

21	1	16.7	1	16.7	4	66.7
22	-	-	4	66.7	2	33.3
23	2	33.3	1	16.7	4	66.7
24	3	50.0	1	16.7	3	50.0
25	2	33.3	1	16.7	3	50.0
26	-	-	2	33.3	4	66.7
27	-	-	2	33.3	4	66.7
28	-	-	3	50.0	3	50.0
29	1	16.7	1	16.7	4	66.7
30	1	16.7	1	16.7	4	66.7
31	1	16.7	1	16.7	4	66.7
32	-	-	3	50.0	3	50.0
33	2	33.3	1	16.7	4	66.7

Table 3 reveals that only eight (8) out of thirty-three (33) items have at least 50% of the total topics where the teachers rate themselves as those who need further training before they can adequately teach the topics. These topics are; Modular Arithmetic, Sets, Simple equation and Variation, Gradient of curves, Circle theorem, Bearing, Latitude, Longitude and Application of linear and quadratic to capital market. These topics are similar to those topics where the teachers rate themselves as the areas where they are having difficulty to teach. Thus, the teachers require further before they can teach these topics competently.

Table 4: Number and percentage of teachers who require further training on some selected topics for senior secondary school teachers.

Items	Very necessary (VN)	Percentage of Necessary	Not Quite Necessary (NQN)	Percentage of Not Quite Necessary	Not Required (NR)	Percentage of Not required
1.	1	05.9	3	17.6	13	76.5
2.	5	29.4	5	29.4	7	41.2
3.	1	05.9	1	05.9	15	88.2
4.	1	05.9	2	11.8	14	82.4
5.	-	-	2	11.8	15	88.2
6.	-	-	4	23.5	13	76.5
7.	3	17.6	9	52.9	5	29.4
8.	5	29.4	8	47.1	4	23.5
9.	5	29.4	5	23.5	7	41.2
10	2	11.8	5	29.4	9	52.9
11	-	-	4	23.5	13	76.5
12	-	-	2	11.8	15	88.2
13	-	-	1	05.9	16	94.1

14	1	05.9	2	11.8	14	82.4
15	1	05.9	6	35.3	11	64.7
16	1	05.9	3	17.6	13	76.5
17	1	05.9	2	11.8	14	82.4
18	3	17.6	4	23.5	10	58.8
19	-	-	5	29.4	12	70.6
20	1	05.9	3	17.6	13	76.5
21	4	23.5	5	29.4	8	47.1
22	4	23.5	4	23.5	9	52.9
23	2	11.8	6	35.3	9	52.9
24	3	17.6	4	23.5	10	58.8
25	2	11.8	2	11.8	13	76.5
26	2	11.8	1	05.9	14	82.4
27	2	11.8	2	11.8	13	76.5
28	2	11.8	3	11.8	12	70.6
29	-	-	7	41.2	10	58.8
30	1	05.9	4	23.5	12	70.6
31	5	29.4	7	41.2	5	29.4
32	6	35.3	5	29.4	6	35.3
33	2	11.8	6	35.3	9	52.9
34	-	-	7	41.2	10	58.8
35	3	17.6	7	41.2	7	41.2
36	4	23.5	3	17.6	10	58.8
37	2	05.9	2	11.8	13	76.5
38	-	-	6	35.3	11	64.7
39	1	05.9	8	47.1	8	47.1
40	1	05.9	7	41.2	9	52.9

Table 4 reveals that only one (1) out of forty (40) items have at least 50% of the total topics where the teachers rate themselves as the topics, they need further training before they can adequately teach the topic. This topic is Logical reasoning. This topic is similar to that topic which the teachers rate themselves as the area where they are having difficulty to teach. Thus, the teachers require further training before they can teach the topics competently.

Conclusions

Based on the findings from this study, the researcher concluded that;

1. There was no significant area(s) in the secondary school mathematics curriculum where mathematics

teachers find it difficult to teach since the teachers perceived about 75.8% (25 out of 33) of the total topic as those topics they feel competence to teach.

2. There was no significant area(s) in the secondary school mathematics

curriculum where mathematics teachers require further training before, they can adequately teach the topics since the teachers perceived about 97.5% (39 out of 40) of the total topic as those topics they feel competence to teach.

Recommendations

Based on the findings from this study, the following recommendations were made:

Regular workshops and seminar should be organized either by ministry of education or relevant governmental and non-governmental organizations to address identified difficult areas where the teachers felt incompetent to teach.

1. Re-fresher training should be organized by the ministry of education on regular bases as the content of mathematics is dynamic in order to improve the level of effectiveness of the achievement of the stated objectives of the content.
2. Finally, it is concluded that, poor performance among secondary school students may not be as a result of difficult topics faced by mathematics teachers in Lare Local Government of education zone of Kaduna State, Nigeria. Thus, poor performance may be as a result of other unexplained factors which may need to be investigated by other researchers.

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BENEFITS AND CHALLENGES OF MATHEMATICS TEACHING AND LEARNING WITH 21ST CENTURY TECHNOLOGY: CASE OF USING ARTIFICIAL INTELLIGENCE

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Abstract

The utilitarian status of Mathematics has been in operation before the teaching and learning of it. That means, Mathematics is natural to man's daily use simply because its concepts are discovered in the environment we live in and in the daily activities. The study traced the phases of teaching mathematics in history to the present day. The primitive approach in teaching, to elegant methods and finally to the machine age were revealed. As it is a common belief that Mathematics is the bedrock of technology, this study pointed out that in contemporary days, proficiency in Mathematics teaching and learning seriously depend on technology, and will still depend on it more in future for its progress. The study considered the potential of teaching and learning Mathematics with the aid of Artificial Intelligence (AI). It explored specific cases by giving algorithms of how some concepts in Mathematics can be taught or learnt by using AI with ease. The paper identified many of the benefits of using AI. Good as it may be, some challenges associated with the use were also elucidated. The paper suggested that teachers and students should begin to explore the use of AI to make teaching and learning of Mathematics easier; that authorities should come up with ethical guidelines for the use of AI in education to avoid abuse. The study concluded with necessary cautions that every user of AI should take.

Keywords: Artificial Intelligence, Mathematics teaching, Adaptive learning system, DreamBox.

Introduction

AI is a computer system that can perform complex tasks which human being can do and this involves human-reasoning, decision-making, creating, and so on. It also includes machine-learning techniques, neural networks, and deep-learning architectures that enable machines to learn from data,

recognise patterns, and make decision on its own. According to publication of The Africa Union Development Agency (AUDA-NEPAD, 2024), AI is a machine-based system that can, for a given set of human-defined objectives, perceive its environment, learn, reason, and interact with the physical or digital world, thereby

performing tasks that typically require human intelligence. That means if AI can reason and take decision like man, then it is truly intelligent. However, since it is not human being, it is artificial. With this paradigm, intelligence has been dichotomously divided as human intelligence and artificial intelligence. Before going further on the use of AI in teaching and learning, it is imperative to consider a brief historical phases of Mathematics usage, teaching and learning. The age of Mathematics usage is dateless in history. Mathematics already existed in nature before man begins to discover it. Although, the early age use is in a simple and primitive form. The study and development of Mathematics in history has been classified into nine phases or ages;

1) The phase of Ancient Civilisation (3000BCE-500CE). This is the era of civilisation in Mesopotamia, Egypt and Greece. As reported by Katz, (2013), the history of study of Mathematics began with these people. They use small objects such as stone, stick or tally to represent the number of cattle and other assets. The study of geometry can be traced to the Egyptians when they measure land for farming activities at the bank of river Nile. 2) The second era is that of Medieval Period (500-1500CE). At this period, the Islamic scholars introduced numerals and algebraic methods. By these they transmitted mathematical knowledge. 3) Renaissance and enlightenment (1500-

1800CE). According to Kline (1972), this is considered as the era of revival of classical Greek Mathematics. It was the time of emergence of modern Mathematics and geometry. 4) Industrialisation and Standardisation period (1800-1900CE). This period witnessed the development of calculus and analytical geometry. According to Boyer (2010), the period witnessed standardisation of notation and terminology.

The 20th century is a prominent era in the development of Mathematics to the intent that three noticeable segments are recognised. These are;

4. The Early 20th Century (1900-1950CE). it was the era of rise of modern Mathematics. Grabiner, (2007) claimed this to be the time of influence of Hilbert and Russell. 6) Mid-20th Century (1950-1980 CE). it was a time of New Mathematics Movement. There was emphasis on abstract structures and set theory according the claim of Phillips (2015). 7) Late 20th Century (1980-2000 CE). This is called the era of Back-to-Basics Movement. Kilpatrick (2001) noted this to be the era of renewed emphasis on fundamental skills and integration of technology into Mathematics. 8) Contemporary Era (2000 CE-date). According to The National Council of Teachers of Mathematics (2014), this era is characterized by focus on problem-based learning, real world application, technology integration, diversity, equity and inclusion.

9) Future Directions. Mayer (2019) by foresight predicted the characteristics or what will be in this era as emphasis on data science, computational thinking, artificial intelligence, interdisciplinary connections and personalized learning.

The implication of Mayer (2019) classification is that the future is here already. It should be noted that Mayer (2019) made his assertion in 2019. Therefore, the future spoken about is any time beyond 2019. Little wonder, that every facet of human endeavour is thinking of application of AI. The activities we do now a days with AI is a confirmation and validation of his prediction.

In the historical antecedents made above, the first mention of integration of technology was by Kilpatrick (2001) at the era of Late 20th century. This was also reiterated by the NCTM (2014) while referring to the Contemporary era of the same 20th century. This shows the high tempo in which technology is taking over a lot of teaching-learning processes. However, it does not imply that technology was not applied in the ages past. How technology has been employed into Mathematics teaching and learning will be the next thing to explore.

Phases of Integration of technology in teaching and learning of Mathematics

The integration of technology in the teaching and learning of Mathematics at various times has transformed the terrine of Mathematics

education. The phases of integration of some of them will be considered in three parts; in the past, present and future.

-Technology integration in *the past*; A pointed out by Katz (2013), Abacus is one of the oldest technologies introduced into the teaching of Mathematics to aid the teaching-learning tasks. Though an old technology, it is still very useful today. It is still in use to teach early learners the concept of place value of numbers.

The Slide Rule. This is a calculating device which was introduced in the 17th century. It is an analog device used to carry out mostly multiplications and divisions. The inception of adding machines (calculator) put an end to the use of slide rule.

Graphing Calculators. This came up in the 1980s. It is used in visualising mathematical relationships. Desmos (2023) spelt out its use in drawing graph of functions and equations.

Computer Algebra Systems. This also came to use in the 1980s. Heid (1988) described it as a device used for symbolic manipulation and problem-solving.

Technology integration in Mathematics teaching and learning in the Contemporary time.

Here are some of the applications, platforms, software and tools that are available for the teaching of Mathematics;

1) Learning Management Systems (LMS): This is an online platform for course

management (Anderson, Boyle & Reiser, 2019). Example of this is the Modular Objective-Oriented Learning Environment (Moodle). A lot of applications such as zoom and some parts of window are embedded in Moodle.

2). Mathematics Software: GeoGebra, Mathematica, MATLAB have also been identified by Hohenwarter and Fuchs (2004). The GeoGebra is a software used for the teaching of geometry, calculus, algebra. Functions. It enhances visualization of geometric shapes.

3). Online Resources: Examples of online resources are Khan Academy, Wolfram Alpha, Mathway (Khan, 2012). TESSA. These are materials made available on the internet. Some may be with little subscription while some others may be completely free.

4). Mobile Apps: Desmos (2020) identified some of these; Photomath, Math Tricks, Desmos. The use of smart board is also an effective technology of communicating Mathematics knowledge. Afolabi and Ajayi (2022) found that smart board has the potential of promoting positive attitude towards Mathematics between male and female without gender bias when Mathematics is taught with smart board.

5). Virtual Reality (VR) and Augmented Reality (AR): These give Immersive learning experiences (Dunleavy & Dede, 2014). The VR uses technology to create scenario virtually and makes the learner to feel like it is

a real-life experience. In Augmented Reality (AR), 3-Dimensional objects are projected with a camera and makes them appear as if they are real object.

6) Artificial Intelligence (AI) and Machine Learning (ML): Adaptive Learning Systems-ALS (Mayer, 2019). ALS makes use of some tasks like a diagnostic test to discover/locate the entry behaviour of the learner to place him on the appropriate learning level. The application begins to vary the parameters and tasks as the learner is responding to the tasks given. The app gradually increases the level of task demand as the learner goes from one stage to the other. Lastly,

7) Online Collaboration Tools: This is like an online forum for students to meet and learn by sharing ideas. Examples of Web-based platforms for student interaction are Google Jamboard, Padlet.

Future Application of Technology in Mathematics Teaching and Learning

The next level of *future* technology integration in the teach and learning of Mathematics will make use of various online software and application Artificial Intelligence of various brand.

1. Intelligent Tutoring Systems (ITS): Personalised learning with AI (Anderson et al., 2019).
2. Blockchain-based Education: Secure, decentralized learning records (Sharples & Domingue, 2016).

3. 3). Virtual and Hybrid Learning Environments: Blending physical and digital spaces (Garrison & Kanuka, 2004).

Mayer (2019), Anderson et al. (2019) in just few years ago, precisely in 2019 alluded to the use of AI in future. By implication, the future they referred to is now. We therefore need to believe that this is the era of AI because the 'future' is now. This awareness should make every stakeholder in Mathematics education to face the reality and join the chariot of the day-AI. Good enough, that in 2020, COVID-19 has compelled a great percentage of stakeholders to migrate to online teaching and learning. And it has come to stay since then. So, COVID-19 has served as a stimulus to prepare the stakeholders to be prepared meaningfully for the use of AI. Consequently, it is to think and learn the '*how*' of AI.

AI is a technology that makes machine to think, act and take decision like man. This is more than the activities of our computers (desktops and laptops) in the sense that AI can act and take decision whereas, computer operates on '*garbage in garbage out.*' AI can handle massive data, analyse and make decision. AI can see, understand and translate spoken and written language. It is the simulation of human intelligence in machines that programmed to think and acts like humans. It is intelligent but not natural intelligence. Hence, the name '*Artificial Intelligence*'

Some Guides and Examples in making use of AI in Mathematics Teaching

The next thing is to provide some guides on how to make use of AI in Mathematics teaching i.e., how it works. Some of this are provided below.

1. The Adaptive Learning System (ALS): This is a learning system in which the AI adapts what an individual will learn to his level of ability. Once the concept is chosen, some questions/tasks are given by the AI. The type of response that the learner gives will diagnose his learning ability. Hence the machine continues from that point. AI continues to vary the parameters in order to engage the learner in varieties of tasks. It goes from simpler tasks to harder ones. This enables the learner to have personalized learning experience. Examples are; DreamBox Learning, Curriculum Associates, i-Ready, uLesson.

2. Intelligent Tutoring Systems (ITS): In this case, the AI plays the role of a tutor. The learner has a personal learning experience as a simulating human tutor (Anderson et al., 2019). An example of this is the Carnegie Learning's Cognitive Tutor.

3. Math Games and Simulations: According to Wiggins (2016), the learner engages in games and simulations that are driven by the AI. By this the learner engages in interactive learning. Examples of this are; Math Playground, PhET Interactive Simulations.

4. Automated Grading and Feedback: The AI grades the learner and give feedback as well. This enables the teacher to have relief from much work (Heffernan & Heffernan, 2019). Examples of this include; Gradescope, Turnitin

5. Natural Language Processing (NLP) Tools: AI-powered NLP tools and it facilitates Mathematics problem-solving, understanding, and communication (Forbes, 2019). Example: Mathway, Symbolab.

6. Virtual Learning Environments (VLEs): According to Garrison & Kanuka (2004), AI creates interactive learning experience. The VLE is powered by AI to create immersive. Example: Khan Academy, Coursera.

7. Real-time Assessment and Analytics: AI-driven analytics provide insights into student performance, informing instruction (Baker & Siemens, 2014). Example: BrightBytes, Renaissance.

Some Examples of Applications AI

It will suffice to consider three cases in using AI to teach Mathematics concepts.

1. Teaching Algebra with AI-powered Adaptive Learning: AI analyses student responses. It then identifies the knowledge gaps and providing personalised exercises. DreamBox Learning's adaptive system uses AI to adjust algebra lessons based on individual students' needs. Stuart (2020) identified the CEO of DreamBox to be Jessie Woolley-Wilson. Wooley-Wilson (2025) said

DreamBox Adaptive engine continuously monitors student interactions and adjusts the difficulty and content to individual's ability and makes them to progress on their own pace. Example: A student struggles with solving linear equations. AI adapts the lesson, offering additional practice and visual aids to reinforce understanding. A DreamBox uses Intelligent Adaptive Learning technology to adjust the difficulty level of lessons based on a student's performance.

2. Exploring Geometry with AI-driven Simulations: PhET Interactive Simulations is a platform developed by the University of Colorado, Boulder. This is some AI-powered geometry simulations which enable students to explore mathematical concepts interactively. AI adjusts simulation parameters, allowing students to investigate relationships between shapes.

Example: Students use the "Geometry Shapes" simulation to discover properties of congruent triangles. AI modifies the simulation, illustrating theorems and proofs.

3. Enhancing Calculus Understanding with AI-assisted Tutoring: Carnegie Learning's Cognitive Tutor uses AI to provide one-on-one calculus tutoring (Carnegie, 2020). AI analyzes student responses, offering real-time feedback and guidance. Example: A student struggles with optimization

problems. AI identifies knowledge gaps, providing step-by-step solutions and explanations.

Here is a presentation on how to teach SSS2 Quadratic Equations

We shall consider algebra because it is a concept which holds a central position in school Mathematics. It is foundational to Pure Mathematics. Most models, functions and relations in physical quantities are expressed in algebraic form. The aspect of algebra to consider is the quadratic equation.

Topic: Quadratic Equations

Objectives: 1. Students will learn to solve quadratic equations using factoring and quadratic formula.

2. Students will apply AI-powered tools to visualize and explore quadratic equations.

Materials:

1. Computers/tablets with internet access

2. AI-powered tools:

- Desmos Graphing Calculator ((link unavailable))
- Mathway ((link unavailable))
- Khan Academy ((link unavailable))

Lesson Plan:

I. Introduction (10 minutes)

1. Introduce quadratic equations, explaining real-world applications.
2. Use Desmos to graph a quadratic equation, illustrating its shape.

II. Factoring Quadratic Equations (20 minutes)

1. Teach factoring methods (e.g., AC Method, Factoring by Grouping).
2. Use Mathway to demonstrate factoring examples, allowing students to explore.

III. Quadratic Formula (20 minutes)

1. Derive and explain the quadratic formula.
2. Use Khan Academy's interactive exercises for students to practice applying the formula.

IV. AI-Enhanced Exploration (30 minutes)

1. Assign students to explore quadratic equations using Desmos:
 - Graph different quadratic equations, observing changes.
 - Investigate relationships between coefficients and graph shapes.
2. Encourage students to use Mathway to check solutions and visualize graphs.

V. Conclusion (10 minutes)

1. Review key concepts and AI-powered tools used.
2. Discuss how AI enhances understanding and exploration of quadratic equations.

Assessment:

1. Students will complete a quiz using traditional methods.
2. Students will submit a Desmos graph illustrating their understanding of quadratic equations.

It is obvious that using AI in Mathematics teaching will be beneficial. Research has highlighted some of the benefits that the use of AI can offer in Mathematics teaching and

learning. Some of those benefits are here outlined.

Benefits of using AI in teaching

There are many benefits in learning to teach with AI and to the students by using it in learning Mathematics. The ability to use it will help both teachers and students to be well placed in the sphere of global competitiveness. As is being developed and used in the developed parts of the world, the developing nations will be able to catch up as well. Many authors and researchers have each pointed out the benefits that they have found to be associated with the use of AI in teaching and learning. Some of them are itemized below.

1. Personalised Learning (Knewton, 2019): AI adapts to individual students' needs, abilities, and learning styles.
2. Enhanced Engagement (Wiggins, 2016): AI-powered interactive tools and games increase student motivation and participation.
3. Real-time Feedback (Heffernan & Heffernan, 2019): AI provides immediate assessment and feedback, facilitating timely intervention.
4. Intelligent Tutoring (Anderson et al., 2019): AI simulates human tutors, offering one-on-one support and guidance.
5. Data-Driven Insights (Baker & Siemens, 2014): AI analyzes learning data, informing instruction and improving student outcomes.

6. Accessibility and Equity (Forbes, 2019): AI-powered tools reach diverse learners, including those with disabilities.

7. Efficient Grading and Assessment (Gradescope, 2020): AI streamlines grading, saving instructors' time.

8. Adaptive Assessments: Woolley-Wilson, (2025) said AI adjusts assessment difficulty, ensuring accurate measures of student understanding.

9. Enhanced Visualization: This is done by using PhET. PhET means Physics Education Technology. It is an interactive simulation project which enable students to visualize science and Mathematics concepts through animated simulations. It freely runs in Apps or browsers. Subjects like Mathematics, Physics, Biology, Chemistry and Earth Science are embedded in it. AI-driven simulations facilitate deeper understanding of complex mathematical concepts. Perkins, Moore, Podolefsky, Lancaster, & Denison, (2011) who worked on PhET emphasized that it makes the students to see the invisible.

10. Continuous Learning (Khan Academy, 2020): AI supports lifelong learning, providing resources for students beyond the classroom.

Good as it may be, the use of AI has some challenges which it can pose on stakeholders in Mathematics education. Literature is not silent on the possible dangers of using AI. Some of these challenges shall be explored now.

Challenges of using AI in Mathematics teaching and learning

It is essential that this study explores the challenges to be faced by the stakeholders (teachers, learners and the society). This will prepare the users mind not to have a hundred percent optimism. They will have the foreknowledge and be ready to mitigate and withstand them. This issue of challenges has been raised and critiqued by many researchers and authors. Various authors and researchers have identified the possible challenges. As given in literature by these authors, such challenges are reported below;

1. Overreliance on Technology (Wiggins, 2016): Excessive AI use can lead to decreased critical thinking skills. The highest level of thinking is creativity (Anderson & Krathwohl, 2001). This may be hindered if critical thinking is reduced.
2. Limited Contextual Understanding (Forbes, 2019): AI may struggle to understand nuanced mathematical concepts.
3. Technical Issues (Baker & Siemens, 2014): AI systems can malfunction, disrupting learning. This is applicable to all learning that depends so much on electronic systems.
4. Lack of Human Interaction (Heffernan & Heffernan, 2019): AI replaces human teachers, potentially diminishing emotional support. Affective learning is equally reduced.
5. Data Privacy Concerns (Knewton, 2019): The data used are mined from any database available to AI irrespective of their

confidentiality. AI systems collect sensitive student data, raising privacy issues.

6. Curriculum Limitations: AI may not cover entire curricula or address specific learning needs.
7. Dependence on Algorithms (Khan Academy, 2020): AI-driven instruction may prioritize algorithms over conceptual understanding. If conceptual understanding is missing the rudiments and the underlying principles, assumptions and conditions attached to an investigation may be lost.
8. Assessment Biases (Gradescope, 2020): AI grading systems can perpetuate biases and inaccuracies.
9. Limited Feedback (Mathway, 2020): AI may not provide detailed feedback. The feedback may not meet individual need, hindering understanding.
10. Equity and Access Concerns (Anderson et al., 2019): Not all students have equal access to AI-powered tools.

Suggestions

It is therefore suggested that the learners and teachers of Mathematics begin to explore the AI and the associated tools, some of which are mentioned in this work. Constituted authorities should also come up and make known the ethical issues that are associated with the use of AI withing the educational settings in order to avoid abuse.

Summary

The use of AI is a mark of progress and technological advancement. There should be no fear of what might be the danger. After all, we have already some social media that are constituting threat to privacy, governance and constituted authorities. Yet, we are still able to exercise some control. AI will relief teacher in teaching and assessment. Mere guidance from the teacher to the learners can make them learn beyond the scope of what the teacher could teach (Afolabi, 2021).

Conclusion

Having considered the pros and cons of AI, it will be a veritable tool to get much achieved within a short time. It is a mark of technological advancement and breakthrough if young learners and their teachers can start the use of it early enough. It will encourage self-learning and reduce teacher' task and at the same time, enhance global competitiveness for teachers and learners.

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The purpose of this work is to sensitise the Mathematics teachers to be aware of various possibilities through technology and AI tools that they can readily explore and use in their profession. The author therefore acknowledges ChatGPT, Meta AI and few other AI tools from which most information were obtained in order to expose the Mathematics teachers to them.

INFLUENCE OF NETWORK GENERATIONS ON MATHEMATICS TEACHER'S IN TEACHING SECONDARY SCHOOL STUDENTS FOR SECURING NIGERIA IN 21ST CENTURY

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Abstract

This study focuses on the influence of Network Generations on Mathematics Teachers in Teaching Secondary School Students for Securing Nigeria in 21st Century. In particular, it investigated effect of using various Communication Networks on Mathematics Teachers pedagogical approaches, teaching strategies and students' achievement. The study was presented through the following sub-headings: Introduction, Brief History of Network Generations, Characteristic of Network Generations, Benefits of 5G in Mathematics Teaching/Learning, The 5G Enabling Technology in Mathematics Education, Challenges of 5G Networks in Nigeria, Conclusions and Recommendations were made such include, Workshops, Seminars, Training and Re-training should be organized for Mathematics teachers on the use of Emerging Technologies 5G by the Ministry of Education periodically among others.

Key Words: Network-Generations, Mathematics Teachers and 21st Century

Introduction

Nigeria and indeed the entire world are at the birth of a technology revolution that is bringing a lot of changing in the way people live, work and relate to one another. This revolution is known as the fourth Industrial Revolution (4IR), there is possibility of billions of people connected by Mobile devices which can be multiplied by emerging technology in field, such as AI, robotics, high-speed broadband which is being boosted by 5G, the internet of things, Autonomous Vehicles (AV), 3-D printing, nanotechnology,

biotechnology, virtual reality (VR), Augmented reality (AR), Extended Reality (XR), Mixed Reality (MR), Energy storage, Quantum Computing, microwave and so on. Like the 1st, 2nd, and 3rd industrial revolution, the 4IR has the potential to raise global income levels and improve the quality of Mathematics teachers, life for population around the world. Emerging technologies have facilitated innovations that increased the efficiency and pleasure of our personal as well as group lives. Also, the monitoring and control of how services from education to

healthcare, power plants, transportation, security, precision agriculture, energy, environment, to government parastatals etc. are managed using emerging technologies.

In recent time, due to the outbreak of covid-19 several millions of students across age groups have moved to online learning, the pandemic also exposed unequal access to technology and the necessary infrastructure to impart knowledge especially Mathematics. To ensure equal access to all robust connectivity is essential across every corner of the country Nigeria.

Network Generations (1G to 5G) can simply refer to as a set of telephone network standards which detail the technological implementation of a particular Mobil system. When one is connected to internet, the speed of his /her internet depends upon the signal strength that has been shown in alphabets like 2G, 3G, and 4G etc right next to the signal bar on your phone screen. The speed increases and the technology used to achieve that speed also changes, for instance 1G offers 2.4 kbps, 2G offers 64kbps and is based on GSM, 3G offers 144 kbps – 2 mbps whereas 4G offers 100 mbps – 1 Gbps and is based on Long- Term- Evolution (LTE) technology.

However, in view of the above researchers deem it necessary that knowledge of Network Generation is essential for Mathematics teachers so that teaching and learning can be

effective and enhance students understanding of mathematics concepts.

Brief History of Network Generations

The brief history focuses on 1G, 2G, 3G, 4G and 5G respectively as follows:

1. First Generation 1G (1970 - 1984)

The first generation of wireless telephone technology communication was based on analogue and speeds up to 2.4kb/s and it allows users to make voice calls within a country. Nippon Telegraph and Telephone (NTT) launched the world's first commercial 1G network in Tokyo in 1979. The Nordic mobile Telephone (NMT) consortium a joint effort of Denmark, Finland, Norway and Sweden rolled out the first cross-border 1G system in 1981.

2. Second Generation 2G (1980 - 1999)

The second generation is simply an upgrade from 1G technology to 2G technology the main difference is that 2G is digital whereas 1G is analogue. Motorola gave us the first handheld phone in 1983, but the network side was built by GSM cooperation, let by European telecom operators and standardized by ETSI. The first call was made in Finland by Radiolinja 1991. Second G have the following futures:

- It implemented the concept of Code Division Multiple Access (CDMA) and Global System for Mobile (GSM).
- Also provide small data services like Short Message Services (SMS) and Multimedia's Services (MMS).
- The maximum speed of 2G with General Packet Radio service (GPRS) is 50kb/s or 1mb/s with enhanced Data Rate for GSM Evolution (EDGE) and voice mail etc.

3. Third Generation 3G (1990 - 2002)

The generation popularly called Mobile internet first introduced by NTT DoCoMo in Japan in 2001. This generation set the standards for most of the wireless technology we have come to know and love today such includes web browsing, email, video downloading, pictures shearing and other smart phone technology were introduced in the third generation.

4. Fourth Generation 4G (2000 - 2010)

4G is the 4th generation of mobile phone communication technology standards, it is a successor to the third-generation standards. The 4G system provides mobile ultra-Broadband speed in gigabits/s, this technology is mostly available worldwide. In March, 2008 the International Telecommunication Union-Radio communications Sector

(ITU-R) specified a set of requirements for 4G standards named the IMT-Advanced. Also, 4G network generation set peak speed requirements for 4G service of 100mbit/s for high mobility communication and 1Gbit/s for low mobility communication. The peak bit rate is further improved by smart antenna arrays for Multiple Input, Multiple Output (MIMO) communications and note also that 4G system does not support a traditional circuit switched telephone service, but all Internet Protocol service (IP) based communication such as (IP) telephony. This was launched by commercial LTE network 2010.

5. Fifth Generation 5G (2010/2015 to date)

The 5G is the new generation of radio systems was launched by south korea, SK Telecom in 2019 and the requirements was set by International Telecommunication Union (ITU) in 2015. The actual networks are built by a global ecosystem of vendors like Huawei, Ericsson, Nokia Samsung and operators worldwide and also 5G network architecture that was deliver extreme broadband, ultra- robust, low latency connectivity and massive networking for human beings and the internet of things. 5G will provide communication capabilities far beyond

previous networks and support much under ecosystem with a broad set of use cases and applications while the past has been about connecting things – improving personal life, optimising business processes, e-teaching/learning plat forms which can be achieved with 5G

Characteristics of Network Generations

Below are some of the characteristics of network generations:

1. The aim of wireless communication is to provide high quality, reliable communication just like wired communication (Optical fibre).

2. Each new generation of services represents a big step in that direction.
3. Each of the generation has standards that must be met to officially use the G- technology.
4. There are institutions in charge of standardizing each generation of mobile technology such as ITU (ITU-T), IEEE, IRTF, IEC, 3GPP, etc
5. Each generation has requirements that specify things like through put, delay etc that need to be met to be considered part of the generation.

Table 1: Summary of Characteristics of Network Generations

Features	1G	2G	3G	4G	5G
Start/Development Technology	1970/1984 AMPS, NMT, TACS	1980/1999 GSM	1990/2002 WCDMA	2000/2010 LTE, WIMAX	2010/2015 MIMO, MMWAVES
Frequency Bandwidth	30KHz 2kbps	1.8GHz 14.4-64kbps	1.6– 2GHz 2mbps	2-8GHz 2000mbps to 1Gbps	3-30GHz 1Gbps and higher
Access system	FDMA	TDMA/COMA	CDMA	CDMA	OFDM/BDMA
Core network	PSTN	PSTN	Packet Network	Internet	Internet

Key:

- FDMA : Frequency Division Multiple Access
- TDMA : Time Division Multiple Access
- CDMA : Code-Division Multiple Access
- BDMA : Beam-Division Multiple Access

- OFDMA : Orthogonal Frequency Division Multiple Access
- WCDMA : Wideband Code Division Multiple Access
- LTE : Long Term Evolution
- WIMAX : Worldwide Interoperability for Microwave Access
- PSTN : Public Switched Technology Network
- MIMO : Multiple Input, Multiple Output
- MWWAVES : Millimetre Wave technology (High frequency band)

Benefits of 5G in Mathematics Teaching and Learning in Secondary Schools

1. It improved interaction between teachers, learners and collaboration among peers.
2. With 5G video conferencing platforms such as zoom will improve in quality and reliability around the globe.
3. 5G offers fast connectivity between teachers and students, even in remote settings.
4. Teachers will save time by not having to work around, delays in connectivity or breaks in audio and video connections and instead focus on the learners.
5. Teachers /Students will be able to upload and download videos and learning materials faster and even have

holograms of guest speakers in their classroom without delays.

6. 5G provide faster communication among teachers and students across geographical area working on group project and assignments as if they are sitting in the same room.
7. 5G regardless of distance or location, 5G empowers teachers/Students to access the same information and exercises as their fellow students and learn at their own pace without losing out on anything.
8. Educators are always striving to personalize learning for students leveraging 5G technology as tools that can help them reach new levels with access to real-time data, longitudinal information, content apps and more.
9. Hence, Virtual teaching assistants has implications for skilling and up skilling as well as technical and vocational education and training (TVET).
10. 5G provide a great network capacity and seamless experience that allows learners to explore complex concepts through zooming, pinching and even touching.

Five Generation Enabling Technologies in Mathematics Education

1. Vast number of digital resources, tools and facilities are in contemporary

higher education which are mainly accessible via smart devices.

2. High quality 360-degree video streaming and live programmes, that is with high quality 360-degree video streaming teachers / learners will experience remote environment as close to real physical attendance.
3. The new education paradigm shift requires remote interactivity to achieve necessary level of learners' experience through Augmented Reality (AR), Virtual Reality (VR), and Extended Reality (XR).
4. The key enabling technologies, communication requirements and example use cases of contemporary Education (Education 4.0) by emphasizing the necessity of 5G mobile communications.
5. Regrettably, pre-5G mobile communication system has serious limitations in terms of data rate, latency, and reliability to enable new education environment.
6. This new education paradigm provides real-time tactile sensing of remote environment to complete remote attendance puzzle which includes, seeing hearing, and feeling, controlling and connecting interactively.
7. This 5G puts stringent constraints on communication network which in turn

has to rely on AI/ML to self-optimize and support dynamic users' demand.

Challenges of 5G Network

1. **Proximity:** while mobile networks are deploying 5G towers and transmitters on a regular basis, proximity remains an issue. To get the best 5G connection you need to be in proximity to a 5G infrastructure.
2. **Spectrum and Bandwidth:** Spectrum and bandwidth are improving as service providers are sharing more of their radio frequency between 4G and 5G. Spectrum is a key consideration in choosing both carriers and equipment, much of the 5G deployment will be over existing 3G and 4G spectrum, enabling backward compatibility with older devices.
3. **No focus on Rural and Remote Locations:** Rural and remote locations have not changed much as the 5G rollouts have focussed on urban areas, but carriers have begun discussing fixed 5G options to connect to home WIFI.
4. **Security:** 5G has a different security model than 3G and 4G as it includes new security capabilities. The good news for businesses is carriers will handle most of this implementation, but for businesses that build network services on top of 5G cellular networks, understanding these new

security model will be critical to ensure they are building comprehensive secure service.

Conclusion In conclusion, therefore the researchers have discussed on the Network generations, brief history of network generations, characteristics of network generations, benefits of G network in Mathematics Teaching/Learning in secondary schools, 5G enabling technology in Mathematics Education, Challenges of 5G network, conclusion and recommendation were made. The study also highlighted if mathematics teachers are well educated and have good knowledge of network generation will go a long way to help in Mathematics Education for securing Nigeria in the 21st Century (Global Village).

Recommendations

The following recommendations were made by the researchers among which are:

1. Workshops, seminars, training and retraining should be organised for Mathematics Teachers on the emerging technologies by the ministry of education periodically.
2. Mathematics Teachers should be provided with adequate training and support to understand the use of network technologies in their teaching.
3. Teachers and Students teaching and learning facilities should be made available for the use of current technologies that are used in the classroom.
4. Mathematics teachers should have smart phones and be educated on how to use the educative software for teaching and learning of Mathematics.
5. Government should provide internet facilities in the secondary school for teachers and students easy of exploring digital technology in other to meet up with 21st century demands.
6. Stable power supply for charging and recharging of the technological gadgets
7. ICT knowledge is a continuously improving mechanism, therefore teachers should encourage to keep abreast with trends of current technological development.
8. The net-neutrality principles states that individuals should be free to access all content and applications equally regardless of the source without internet service providers discriminating against specific online service or websites (all content are treated equally without bias).

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EFFICACY OF ETHNOMATHEMATICS APPROACH ON ACHIEVEMENT AND INTEREST OF SENIOR SECONDARY STUDENTS IN MATHEMATICS ACROSS SCORING LEVELS

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Abstract

This study was carried out to determine the efficacy of ethnomathematics in bridging the gap between low, medium and high scoring students' achievement and interest in Mathematics. The study was carried out in Ilorin Kwara State, Nigeria using a sample size of 140 senior secondary Two (SS2) students. The study employed Quasi- experimental design of non-equivalent, non-randomised, pre-test, and post-test control group design. Intact classes were used for both the treatment and control groups. The treatment group was taught using ethnomathematics approach while the control group was taught using the conventional method. Two research questions and two research hypotheses were formulated to guide the study. Mathematics Achievement Test (MAT) and Mathematics Interest Scale (MIS) was used as the instruments with reliability coefficient of 0.77 and 0.73 respectively. MAT and MIS were used as pre and posttests though reshuffled each time for data collection. Mean and Standard deviation were used to answer all the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. The results revealed among others that ethnomathematics was more efficient in facilitating and improving high, medium and low scoring students' achievement and interest in sequence and series than the conventional method. The ethnomathematics did not significantly differentiate among high, medium and low scoring students' achievement and interest scores in sequence and series. The finding implies that ethnomathematics is suitable for enhancing inclusive learning outcome across scoring level. Based on the findings, it was recommended among others that Mathematics teachers and students in Nigerian senior secondary schools should embrace the use of ethnomathematics approach for all-inclusive achievement and interest of all the scoring levels in Mathematics.

Keywords : *Ethnomathematics, Achievement, Interest, Score levels, Sequence and Series*

Introduction

Ethnomathematics emphasizes the integration of cultural contexts into mathematics education, fostering students' development and learning by connecting mathematical concepts to their cultural experiences. This approach necessitates teaching materials that relate mathematics to real-life situations and societal

cultures. Ethnomathematics serves as a tool for generating, transmitting, and diffusing knowledge, with emphasis on the learner's sociocultural environment (Rosa & Orey, 2021).

It builds upon students' prior knowledge, backgrounds, and environments, incorporating content, methods, and experiences from their

immediate surroundings. Implementing ethnomathematics in a culturally relevant mathematics classroom involves teachers leveraging students' existing knowledge and directing lessons toward their cultural experiences while developing critical thinking skills (Santos & Rosa, 2022). Recent research has demonstrated that ethnomathematics-based instruction significantly improves students' mathematical literacy compared to conventional teaching methods (Sari et al., 2024).

Ethnomathematics positions mathematics as a human activity embedded in culture, language, and daily practices. Rather than presenting mathematics in abstract isolation, the approach draws on cultural contexts, thereby making mathematical ideas more meaningful to learners. D'Ambrosio (2010) argued that ethnomathematics builds on students' prior knowledge, background, and cultural environment, while Rosa (2010) emphasized its potential to connect learners' real-world experiences to formal mathematical models. Weldeana (2016) further described ethnomathematics as fertile ground for promoting mathematical understanding because it bridges local practices with school mathematics.

Ethnomathematics has increasingly been examined as an independent variable in mathematics education research, often positioned as an instructional strategy that

influences achievement, retention, and interest. A recent meta-analysis demonstrated that ethnomathematics-based learning significantly improves students' mathematical literacy compared to conventional methods. The effectiveness of the approach was observed at the lower levels of education where learners often struggle most (Imroatus Sholihah, 2024). Similarly, Garba (2024) found that the ethnomathematics instructional approach, when combined with problem-based learning, had a significant positive effect on junior secondary students' achievement, interest, and retention in geometry in Benue State. These findings reinforce the position of ethnomathematics as a viable independent variable capable of driving broad learning gains.

The concept used in this study is sequence and series. This is because sequence and series naturally appear in cultural contexts, making them suitable for ethnomathematical exploration. For instance, patterns in traditional crafts, architecture, and games can be used to illustrate the progression of sequences. Akanmu (2013) highlighted the importance of guided discovery in enhancing students' mathematical performance, and when applied to sequence and series, such discovery can be grounded in familiar cultural experiences. Therefore, ethnomathematics provides a culturally anchored platform for

teaching a concept that is both abstract and essential.

Secondly, sequence and series form the foundation for later topics such as calculus and advanced algebra; a weak grasp of these concepts often leads to persistent difficulties in higher mathematics. Ayinla (2011) noted that instructional strategies have a significant impact on students' ability to solve mathematical word problems, with lower-scoring students benefiting most. This suggests that difficult yet foundational topics such as sequence and series require innovative teaching approaches that support all scoring levels.

Students' performance in mathematics is influenced by various factors, including scoring levels, which categorize learners as high, medium, or low scorers based on standardized criteria. In most educational settings, these scoring levels are determined either by individual scores or relative performance within the group. Schools, as structured social institutions, have a critical role in fostering systematic thinking and intellectual growth. Accordingly, the introduction of effective teaching strategies, particularly culturally responsive ones can enhance mathematics achievement among all learners (Agyei, 2023).

Scoring levels are typically classified as high, medium, and low achievers, usually based on pretest performance or past academic records.

This variable is often treated as a moderator in intervention studies, helping to reveal whether an instructional strategy benefits certain groups more than others. Brookhart (2013) defined performance levels as categories for interpreting assessment results and stressed their diagnostic value in guiding instruction. Guskey (2018) further argued that analyzing instructional interventions by scoring levels is essential for determining whether they narrow or widen achievement gaps.

Scoring levels are widely used in educational research to classify students' performance and to analyse how instructional strategies affect different groups of learners. They provide a framework for understanding learning gaps and for designing targeted interventions. Abdulwahab (2014) defined scoring levels as groupings into high, medium, and low categories, typically based on test performance. Brookhart (2013) described scoring levels as performance categories used to interpret test results, while Black and Wiliam (2009) noted that scoring levels are central in formative assessment practices, helping teachers identify learners who require additional support.

In mathematics education, scoring levels have been consistently employed to evaluate the differential impact of instructional approaches. Guskey (2018) emphasized that high, medium, and low scoring groups are essential for measuring instructional effectiveness,

particularly when innovative methods are introduced. Studies such as Ayinla (2015) and Akanmu (2013) confirmed that scoring levels can reveal how strategies benefit students differently — with some strategies favouring low achievers and others benefitting high achievers more.

Studies also confirm the importance of scoring levels. For instance, Fajemidagba, Salman, and Ayinla (2012) reported that instructional strategy patterns helped low scorers more than high scorers, while Anyanwu, Ezenwa, and Gambari (2013) found no significant differences across score levels when using computer-based multimedia instruction. These findings underscore the importance of examining scoring levels when evaluating the efficacy of new approaches, such as ethnomathematics.

In the classroom, this approach provides multiple entry points for learners by linking mathematical content to cultural artefacts, games, and everyday practices. This inclusivity can help both high and low scorers engage meaningfully. Changwe and Mwanza (2019) reported that inconsistent mathematics performance in Zambia was partly due to limited use of ethnomathematics pedagogy, suggesting that proper integration can foster greater participation and comprehension. By making mathematics culturally relevant and contextual, ethnomathematics enhances both

motivation and cognitive understanding across diverse groups of learners.

Recent findings suggest that ethnomathematics tends to function as an equalizer across scoring levels. For instance, the meta-analysis by Imroatus Sholihah (2024) highlighted that learners with lower baseline abilities often showed stronger improvement under ethnomathematics-based approaches. Similarly, Garba (2024) reported that while all learners benefitted from ethnomathematics-based geometry instruction, there were no significant differences between high, medium, and low scoring groups in posttest results. This indicates that ethnomathematics can improve performance inclusively, reducing gaps across scoring levels and making it a promising variable in addressing disparities in Nigerian classrooms. This therefore necessitate the study that sought to determine the efficacy of ethnomathematics on achievement and interest of senior secondary students in mathematics across scoring levels.

Statement of the Problem

Performance in Mathematics among Nigerian secondary school students has continued to generate concern for educators, researchers, parents, and policymakers. Reports from the West African Examinations Council (WAEC) consistently show that a large proportion of candidates at the Senior Secondary level (SS I–SS III) record below-average results in

Mathematics. Despite various interventions, achievement gaps remain evident among high, medium, and low scoring students. This persistent challenge raises questions about whether instructional methods currently used in Nigerian classrooms are adequate to support learners across all ability levels.

Several studies have reported conflicting findings regarding the groups of students who benefit most from specific teaching strategies. For example, Ayinla (2015) found that low scorers in SS III benefited more when exposed to Curriculum-Based Measurement, whereas Akanmu (2013) reported that high scorers in SS I gained the most from guided discovery learning. Salman, Ayinla, Adeniyi, Ogundele, and Ameen (2012) also showed that problem-solving instructional strategies tended to favour high-scoring students, while Fajemidagba, Salman, and Ayinla (2012) reported that instructional strategy patterns provided more benefits for low scorers. These inconsistencies create uncertainty for teachers who aim to address the needs of diverse learners in mixed-ability classrooms.

Another problem is that traditional methods of teaching Mathematics in Nigerian classrooms often focus on rote procedures and abstract symbols with little connection to learners' real-life experiences. Black and Wiliam (2009) observed that such approaches do not sufficiently address performance gaps across scoring levels. In many SS II classrooms,

where topics such as Sequence and Series are introduced, low and medium scorers struggle to see the relevance of abstract rules, resulting in poor retention and weak transfer to problem-solving contexts. The failure to situate Mathematics within cultural practices further alienates learners, particularly those already classified as low scorers.

Given these challenges, there is a pressing need for alternative instructional strategies that can reduce gaps among scoring levels while improving overall achievement and interest. Ethnomathematics, which emphasizes the integration of cultural artefacts, games, and practices into Mathematics teaching (D'Ambrosio, 2010; Rosa, 2010; Weldeana, 2016), presents itself as a promising approach. However, limited empirical research in Nigeria has tested its efficacy specifically in bridging achievement and interest gaps among SS II students in topics such as Sequence and Series. This study therefore seeks to determine the efficacy of ethnomathematics in addressing these long-standing problems of differential performance across high, medium, and low scoring students in Mathematics.

Objective of the Study

The aim of this study was to determine the efficacy of Ethnomathematics among high, medium and low scoring students' achievement and interest in Mathematics.

Specifically, the study examined the difference in:

1. Achievement of high, medium, and low scoring students taught sequence and series using Ethnomathematics; and
2. Interest of high, medium, and low scoring students taught sequence and series using Ethnomathematics.

Research Questions

The following research questions were answered in this study.

1. Is there any difference in the achievement mean scores of high, medium and low scoring students taught sequence and series using Ethnomathematics approach?
2. Does variation exist in the interest mean scores of high, medium and low scoring students that were taught sequence and series using Ethnomathematics approach?

Research Hypotheses

The following research hypotheses were tested at 0.05 level of significance.

H₀₁: there is no significant difference in the achievement mean scores of high, medium, and low scoring students taught sequence and series using Ethnomathematics approach.

H₀₂: there is no significant difference in the interest mean scores of high, medium, and low scoring students taught sequence and series using Ethnomathematics approach.

Methodology

The study adopted a quasi-experimental design of non-randomised, non-equivalent, pre-test, and post-test control group of 2 X 3 factorial design. Where 2 in the design representing the treatment and control group and the 3 is representing the low, medium and high scoring levels. This study was conducted in Ilorin, Kwara State, Nigeria using the Senior Secondary school students. The sample size composed of 75 male and 65 female senior school two (SS II) students drawn from two intact classes. The choice of SS II students was based on the premise that the concept of sequence and series is taught in that level. The instrument for this study was Mathematics Achievement Test (MAT) and Mathematics Interest Scale (MIS). The MAT consists of thirty (30) multiple-choice test items on sequence and series adapted from the recommended Mathematics textbook to sweet the purpose of the study. The sequence and series was chosen as the concept of this study because it serves as the foundation for later topics such as calculus and advanced algebra. Also, a weak grasp of these concepts often leads to persistent difficulties in higher mathematics

The MAT contains two sections: sections A and B. Section A describes background information about the respondents. These include the sex and name of the school, while section B contains 30 multiple-choice questions on sequence and series. The questions were adapted from the recommended mathematics textbooks. Each question contains four options A-D which the students were expected to choose the correct option that answers the question and each of the test items attracted 1 mark and the total mark is 30. The MIS is a questionnaire consisted of two sections A and B. Section A sought the students' biography while section B consisted of 20 questions directed toward eliciting responses to determine each student's interest in Mathematics. This implies that the questionnaire determined whether students have high or low interest in Mathematics before and after being exposed to Ethnomathematics mode of instruction.

The reliability of MAT was determined using the test-re-test method. The test instrument was administered to 41 SS II students that did not participate in the main study. After two weeks, the test items were shuffled and re-administered on the same set of students. Their scores in the two tests were correlated using the Pearson Product Moment Correlation statistics. The reliability index for the MAT was found to be 0.77. The reliability index for MIS was determined using test-re-

test method. The test items were administered to 41 SSII students selected from the secondary schools that were not among those selected for the study. After two weeks copies of the test items were shuffled and re-administered on the same set of students. The scores in the two tests were correlated by the researcher and its internal consistency value was 0.73 using Pearson Product Moment Correlation statistics.

The lesson notes that had been subjected to series of corrections by the experts in the field of mathematics education was used to teach the experimental group using Ethnomathematics approach that comprise of cultural materials, activities and artifacts related to sequence and series. The cultural materials includes; Moringa leave, traditional board game, aso oke and counting system in Yoruba language. While the control group was taught using the conventional method. The MAT and MIS were administered to the two schools as pre-test.

Also, the MAT and MIS were re-administered as post-test and questionnaire respectively to both groups. The items of the instruments were the same as those used for the pre-test, although the researcher shuffled them. After the administration of the post-test, the marking and recording of the post-test of the MAT was done before subjecting the scores to analysis. The researcher also re-administered the MIS Questionnaire to gather data on students'

interest in solving Mathematics after the application of the treatment.

Descriptive statistics were used to answer research questions using mean and standard deviation. The inferential statistics were used to test the corresponding hypotheses using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The Statistical Package for Social Science (SPSS) 20 version was used to carry out the analysis.

Results

The result of the analysis is presented in table 1, 2, 3 & 4. The hypotheses were tested at 0.05 level of significance.

Research Question 1: Is there any difference in the achievement mean scores of high, medium, and low scoring students taught sequence and series using Ethnomathematics approach?

Table 1: *Mean and Standard Deviation Computation Results of students' Achievement in Experimental Group based on Score Levels.*

Treatment	Score Levels	N	M	SD
Ethnomathematics Approach	High	13	18.00	2.48
	Medium	30	18.33	2.92
	Low	32	19.09	3.02

Table 1 indicates marginal differences in the mean score of the high scoring ($M=18.00$), medium scoring ($M=18.33$), and low scoring ($M=19.09$) students that were taught sequence and series using Ethnomathematics approach. These results suggest that score levels did not have influence on the students' achievement in sequence and series using Ethnomathematics approach. The research question one was transform to hypothesis one in order to test for the significant of the answer obtained as thus.

Hypothesis 1: There is no significant difference in the achievement mean scores of high, medium, and low scoring students taught sequence and series using Ethnomathematics approach.

Table 2

Summary of the ANCOVA Computation Results of Students in the Experimental Group's Achievement in Sequence and Series based on Score Levels.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected model	41.86 ^a	3	13.95	172	0.17	0.07
Intercept	430.00	1	430.00	52.99	0.00	0.43
Pretest	27.24	1	27.24	3.36	0.07	0.05
Score Levels	15.19	2	7.60	0.94	0.40	0.03

Error	576.15	71	8.12
Total	26556.00	75	
Corrected Total	618.00	74	

a.R squared =0.07 (Adjusted R squared = 0.03)

Note df = Degrees of Freedom; F =Fisher's F ratio; η^2 =Partial Eta square

The ANCOVA output in Table 2 shows that $F_{(2,71)} = 0.94, p > 0.05$. This result indicates that the p-value is greater than 0.05 significant level. Therefore, hypothesis 1 was not rejected. This implies that there was no significant difference in the achievement of high, medium, and low scoring students taught sequence and series using Ethnomathematics approach.

Research Question 2: Does variation exist in the interest mean scores of high, medium, and low scoring students that were taught sequence and series using Ethnomathematics approach?

Table 3

Mean and Standard Deviation Computation Results of students in the Experimental Group's Achievement in Sequence and Series.

Treatment	Score Levels	N	M	SD
Ethnomathematics Approach	High	13	62.31	7.79
	Medium	30	60.77	8.10
	Low	32	62.03	8.13

Table 3 indicates a marginal difference in the mean score of the high scoring ($M=62.31$), medium scoring ($M=60.77$), and low scoring ($M=62.03$) students that were taught sequence and series using Ethnomathematics approach. These results suggest that students' score levels did not affect their interest when taught sequence and series using the Ethnomathematics approach. The significant of the result obtained from the research question two are tested in hypothesis two as thus.

Hypothesis 2: There is no significant difference in the interest mean scores of high, medium, and low scoring students taught sequence and series using Ethnomathematics approach.

Table 4

Summary of the Analysis of Covariance Computation Results of High, Medium, and Low Scoring Students taught Sequence and Series using Ethnomathematics Approach.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	42.20 ^a	3	14.08	0.21	0.89	.01
Intercept	8378.00	1	8378.00	127.26	0.00	.64

PreInterest	8.96	1	8.96	0.14	0.71	.00
ScoreLevels	27.84	2	13.92	0.21	0.81	.01
Error	4674.14	71	65.83			
Total	289062.00	75				
Corrected	4716.35	74				
Total						

a. R Squared = .009 (Adjusted R Squared = -0.03)

Note df = Degrees of Freedom; F = Fisher's F ratio; η^2 = Partial Eta square

The Analysis of Covariance (ANCOVA) result in Table 4 shows that $F_{(2,71)} = 0.21, p > 0.05$. This result indicates that the p-value is greater than the 0.05 significant level. Therefore, hypothesis 2 was not rejected. This implies that there was no statistically significant difference in the interest of high, medium, and low scoring students taught sequence and series using Ethnomathematics approach.

Discussion of Findings

This study aimed to examine the efficacy of Ethnomathematics in bridging the achievement and interest gaps among high, medium, and low-scoring students in sequence and series. The findings revealed a notable difference in the achievement levels of students categorized by their performance scores when taught using the Ethnomathematics approach. This aligns with the study by Gambari and Ameen (2023), who observed that Ethnomathematics had a positive effect on student engagement and achievement across various learner categories. The reason for this variation in achievement could be attributed to the inclusive nature of the Ethnomathematics approach, which pairs students of different performance levels, regardless of their individual scores, to engage collaboratively.

This finding supports the notion that Ethnomathematics can be universally applied, promoting learning outcomes for students at different achievement levels, as suggested by Alreshidi (2021) who found similar inclusivity in problem-based learning. The Ethnomathematics approach used in this study, particularly through activities like the traditional board game, emphasized hands-on, culturally relevant activities, which were found to be equally beneficial across all performance categories. This suggests that the Ethnomathematics approach is adaptable and can be employed across diverse student groups. This finding is in contrast to the work of Ayinla (2015), who reported significant performance differences between high, medium, and low achievers when using Curriculum-Based Measurement (CBM). While CBM showed distinct advantages for

lower-scoring students, the Ethnomathematics approach presented a more balanced outcome for students at all levels, highlighting its potential for bridging achievement gaps.

In terms of student interest, the study found no significant differences in the mean interest scores between high, medium, and low scoring students when taught using the Ethnomathematics approach. This suggests that the approach was equally effective in engaging students, regardless of their initial performance levels. The non-discriminatory nature of the Ethnomathematics approach, as evidenced by this study, supports findings by Anyanwu, et al (2023), who found that computer-based multimedia instruction similarly did not differentiate between the interest levels of students across different scoring categories. The Ethnomathematics approach in this study seemed to maintain students' interest in the subject matter of sequence and series, fostering a deeper connection with the material that transcended their scoring levels.

The uniformity in interest across performance levels could be attributed to the cultural relevance and collaborative elements embedded in the Ethnomathematics activities, which foster inclusivity and engagement among all students. By integrating culturally responsive teaching strategies, the Ethnomathematics approach appears to create a learning environment where students of

varying abilities can interact meaningfully with the content and with one another, thus maintaining interest and motivation in the subject.

In summary, the findings of this study suggest that the Ethnomathematics approach is a viable strategy for improving both achievement and interest in mathematics across high, medium, and low-scoring students. These findings are consistent with recent research indicating that Ethnomathematics can help bridge gaps in student performance and engagement (Gambari & Ameen, 2023; Alreshidi, 2021). Furthermore, the study highlights the potential for Ethnomathematics to be a versatile and inclusive tool in mathematics education, capable of benefiting diverse student groups without favoring any particular scoring category.

Conclusion

This study concluded that the Ethnomathematics approach is highly effective in enhancing the achievement and interest of high, medium, and low-scoring students in sequence and series, compared to traditional teaching methods. The study demonstrated that the approach is not only suitable for teaching sequence and series, but it also accommodates students at different scoring levels, making it a versatile tool for inclusive learning. Furthermore, the

Ethnomathematics approach proved to be effective in maintaining and even increasing students' interest in the subject, regardless of their initial performance levels. In light of these findings, it can be concluded that the Ethnomathematics approach is an appropriate and beneficial strategy for improving both achievement and interest in the learning of sequence and series.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. The Ethnomathematics approach should be integrated into the teaching of sequence and series for students at all scoring levels to foster inclusive and effective learning.
2. Mathematics educators should adopt the Ethnomathematics approach as a means to enhance student interest in sequence and series, ensuring that all students, regardless of their achievement levels, are equally engaged and motivated.

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EXAMINING THE ITEM PARAMETERS OF THE 2018 WASSCE MATHEMATIC OBJECTIVE TESTS IN LAGOS STATE, NIGERIA

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Abstract

This study examined the Item Parameters of 2018 West Africa Examination Council's Mathematics Objectives Tests Items in Lagos, Nigeria. The research design used for the investigation is a descriptive survey design. The population included all SS3 students who enrolled for the 2020 WASSCE in Lagos state. Multistage sampling process was used to select 1334 students from eighteen secondary schools (three schools from each educational district). Three research questions guided the study. The research questions were subjected to item parameters analysis using 3-parameter logistic item response theory model. Results demonstrated that Form 3 discriminated examinees with the required ability from the examinees without the required ability more than form 1 and form 2, Form 2 was more difficult, followed by form 1 and then form 3. The result further shows that Form 3 items were more vulnerable to guessing, followed by form 1 and then form 2 and that there was significant difference in the discrimination parameters of the three forms of 2018 WASSCE mathematics objective test items. It was thus recommended that examination bodies and test developers should review the item parameters and test design of the WASSCE Mathematics Objective Tests to ensure consistency and fairness across all test forms. They should also address any significant differences in item difficulty and discrimination identified in the analysis.

Keynotes: WASSCE, Item parameters, Mathematics, IRT.

Background to the Study

Assessment can involve information-seeking processes, instruments, collection methods, and interpretation procedures. The purpose of assessment during teaching and learning is multifold. It not only assures the student's ability to grasp the knowledge imparted but also helps to evaluate the effectiveness of teaching strategies. Therefore, the assessment

process should be both effective and trustworthy.

Assessment outcomes provide valuable information that can be used to improve educational activities. As such, the appropriate development and use of these assessments are essential for responsible professional practice in educational testing and measurement. For examination bodies that administer multiple

test forms over time, it is critical to maintain a stable reporting scale so that scores remain comparable across years, administrations, and test forms.

In Nigeria, teachers create various tests to evaluate students' abilities, proficiencies, and curriculum-related achievements (Agah, 2013). According to Nworgu (2003), a test is a structured situation that includes a set of questions to which an individual is expected to respond. Each question in the test typically has a correct answer.

However, both teachers and external examiners face significant challenges in assessing students fairly and accurately. Issues such as developing equitable tools, minimizing testing difficulty, and generating valid scores remain prevalent. Duze (2011) opined that the current Nigerian educational system is far from achieving its desired goals and objectives. This is evident in the decline in academic standards, particularly reflected in students' poor performance in public examinations.

Evidence of this decline is clearly visible in both internal and external examination results across various subjects, including Mathematics. However, recent trends show that students' performance in Mathematics is beginning to improve gradually in public examinations (see Table 1.1).

Aliyu (2015) regards Mathematics as the bedrock of science and technology. Adeyegba, as cited in Ojerinde (2013), observed that there is hardly any field of science that does not utilize mathematical concepts to explain its theories, models, or ideas.

The performance of students in Mathematics at the West African Senior School Certificate Examination (WASSCE) level in Nigeria is gradually becoming more encouraging (see Table 1.1). Nonetheless, one might expect final-year candidates to consistently achieve at least 80% success in this critical subject, given its importance to national development. Unfortunately, this has not yet been the case, as performance statistics from WASSCE between 2014 and 2018 (shown in Table 1) reveal.

Table 1: Statistics of Performance in Mathematics between 2014 and 2018 in Nigeria

SUBJECT MATHEMATICS	YEAR	TOTAL ENTRY	TOTAL SAT	TOTAL CREDIT 1-6	TOTAL PASS 7-8	FAIL
	2014	1655794	1632377 (98.59)	1037245 (62.64)	383191 (23.14)	211941 (12.98)
	2015	1602362	1581420 (98.69)	918939 (57.35)	442722 (27.63)	219759 (13.89)
	2016	1552169	1536643 (98.99)	1075704 (69.30)	329184 (21.21)	131755 (8.57)
	2017	1565106	1550348 (99.05)	1310816 (83.75)	194658 (12.44)	44874 (2.89)

2018	1576465	1563457 (99.17)	1237050 (78.47)	249398 (15.82)	77009 (4.92)
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Source: The West African Examinations Council (WAEC), Test Development Division, Ogba (2014-2018).

Although the performance of students showed improvement between 2015 and 2018, there is still room for growth. A consistent achievement of at least eighty percent at the credit level is desirable and would represent a significant milestone in academic performance.

The West African Senior School Certificate Examination (WASSCE) is a pivotal assessment tool for secondary school students across West African countries, including Nigeria. This paper focuses specifically on one component of the WASSCE—the Mathematics Objective Tests. This examination plays a critical role in determining students' academic success and their preparedness for higher education.

To improve performance, many interventions have been suggested. One of the most notable is the National Mathematics Centre's (NMC) Mathematics Improvement Programme (MIP), which aims to introduce new teaching methodologies to enhance students' performance in Mathematics. Despite this initiative, students' performance remains inconsistent (Oguoma, Metibemu & Okoye, 2016).

A key challenge lies in the difficulty examiners face when developing fair and

equitable tests—especially in Mathematics. According to Olonode (2016), examiners struggle with designing items that fairly assess students' abilities while minimizing undue difficulty. Rover (2005) defines a fair test as one that gives all candidates an equal opportunity to demonstrate relevant skills and knowledge. This concern brings to light the importance of analyzing item parameters in test development.

The psychometric properties of a test instrument—referred to as item parameters—are statistical indicators used to evaluate the quality of test items. These properties help determine how well a test functions. Though not statistics in themselves, item parameters are represented by quantitative values typically derived from statistical procedures. Common psychometric properties include item difficulty indices (b), item discrimination indices (a), and guessing indices (c).

The difficulty index (b) estimates how easy or hard a test item is for candidates. Easier items have lower (often negative) difficulty indices, with very easy items scoring below -2. Conversely, more difficult items have higher (positive) values, with very hard items scoring above 2. The item discrimination index (a), on the other hand, reflects an item's effectiveness

in distinguishing between high-performing and low-performing students. This value usually ranges from -1 to +1, with higher positive values indicating greater discriminative power.

As of 2018, WAEC conducted three versions of the WASSCE. The first is WASSCE (PC) Series 1, held in January/February. The second is WASSCE (SC), administered in May/June—also known as the Senior School Certificate Examination (SSCE). This version targets students in both public and private schools, and candidates are required to wear school uniforms as per institutional guidelines. Results are typically released in August. The third version is WASSCE (PC) Series 2, conducted in November/December. Previously known as the General Certificate Examination (GCE), this version is open to both private and public candidates, though school uniforms are not mandatory. It is also referred to as the "private examination."

Mathematics, as a subject, plays a crucial role in all aspects of human life and is fundamental in science and technology. In the educational context, Mathematics is the foundation for all scientific and technical disciplines. Its relevance cannot be overstated. As a core subject, it is compulsory for all students in secondary school—regardless of whether they are science or arts-oriented. Therefore, any

examination instrument in Mathematics must be both valid and reliable.

This study focuses on the 2018 WASSCE Mathematics Objective Tests. It explores the item parameters to better understand the quality and effectiveness of these tests in Lagos State, Nigeria.

Theoretical Framework

A test can be studied from various theoretical perspectives, and the items within a test can be evaluated and equated based on the frameworks provided by these theories. This study is anchored on **Item Response Theory (IRT)**, which has its foundational roots in **Classical Test Theory (CTT)**. Consequently, both theories are relevant and applicable to this research.

Classical Test Theory (CTT) operates on the assumption that each test-taker has a **true score**—a fixed, underlying ability level—which would be revealed in the absence of measurement errors. It focuses on the test as a whole and assumes that the measurement error is the same for all examinees.

In contrast, **Item Response Theory (IRT)** is a more modern approach that models the relationship between an individual's latent trait (ability level) and their probability of giving a certain response to a specific test

item. IRT views test performance as a function of both the examinee's ability and

the properties of the test items. These item properties—known as **item parameters**—typically include item difficulty, discrimination, and guessing indices.

IRT is particularly useful in evaluating test items on an individual level and allows for **more precise and flexible assessment** across different forms of a test. By applying IRT, one can understand how different items function for individuals with varying ability levels, which is critical in large-scale standardized assessments.

Statement of the Problem

In large-scale testing programs, it often becomes necessary to develop **multiple forms** of a test (e.g., parallel or alternate forms). This approach is used to prevent overexposure of test items, thereby maintaining the security and integrity of the assessment. However, the use of different test forms raises an important concern: **How can we ensure the comparability, credibility, and reliability of scores** generated from different versions of the same examination?

When students are administered different forms of a test, there is a possibility that variations in item difficulty or test structure may lead to **inequitable outcomes**. For

instance, Student A might perform better on Form Y, while Student B might excel on Form X—not because of differences in ability, but because of discrepancies in test form difficulty.

Given the high-stakes nature of standardized examinations like the WASSCE, it is critical that scores reflect true ability and are not influenced by test form variation. Ensuring **equivalence across test forms** is essential so that results can be used interchangeably without giving any group of students an unfair advantage.

One way to address this challenge is through the examination of **item parameters**, particularly using models from Item Response Theory. By analyzing and equating these parameters across test forms, examination bodies can uphold the **fairness, validity, and consistency** of the assessments. This is especially important in settings where examining boards have flexibility regarding test administration schedules and formats, as it ensures that all students are assessed under conditions that are **equally rigorous and just**.

Research Questions

The accompanying questions guided the study:

1. Are there significant differences in the item difficulty indices among the three forms of 2018 WASSCE Mathematics objective tests, (WASSCE (PC) Series

- I, WASSCE (SC) and WASSCE (PC) Series II)?
2. Do the three forms of the 2018 WASSCE Mathematics objective tests exhibit significant variations in their discrimination indices?
3. Are there significant differences in the guessing indices of the three forms of the 2018 WASSCE Mathematics objective tests?

Methodology

Research Design

The research design used was a descriptive survey design. The design is suitable because it is capable of studying large and small populations by selecting and studying samples chosen from the population to discover the relative incidence, distribution and interrelations of sociological and psychological variables (Ilogu, 2005).

Population

The populace for the investigation comprised of all the 48,651 SS3 students in both public and private secondary schools in Lagos, who enrolled for 2020 WASSCE.

Sampling Techniques

Multistage sampling process was adopted to select 1334 students from eighteen schools, three schools from each of the six educational districts; comprising of public, private, urban and rural areas of Lagos state. Stratified random sampling method was first used to select six local government areas (one per educational district), while simple random sampling technique was later used to pick three schools from each of the educational districts. The SSIII students in the selected schools were used for this study. The distribution of the respondents is as shown in Table 2.

Table 2: Distribution of Respondent across School Location and School Type

School location	School Type		Total
	Private	Public	
Urban	4	5	9
Rural	5	4	9
Total	9	9	18

Instrumentation

The research instruments used for this study were the **adopted 2018 WASSCE Mathematics multiple-choice test items**, specifically from the following test forms: **WASSCE (PC) Series I**, **WASSCE (SC)**, and

WASSCE (PC) Series II. Each item on these tests consisted of **four options (A to D)**, with one correct option and three distractors.

The content of the test items was drawn from the **Senior Secondary School Mathematics curriculum (SS1 to SS3)** as implemented in

Lagos State. These items were considered both **reliable and valid**, having been **pre-validated by the West African Examinations Council (WAEC)** as part of their standardized assessment processes.

Data Collection Procedure

Data collection was carried out over a period spanning **August to September 2019**. The researchers visited each of the sampled schools and **spent two days per school** administering the tests. Prior to this, permission was obtained from the school authorities to conduct the study. The researchers also used this opportunity to establish **rapport with the Mathematics teachers and students**, which helped foster a cooperative atmosphere for the test administration.

To encourage active and sincere participation, the students were **counseled to take the test seriously**. As a motivational strategy, it was announced that **prizes would be awarded to the top three performers** in each school. This incentive helped to increase the level of

engagement and effort put into the test by the students.

Each student was given **90 minutes (1 hour and 30 minutes)** to complete the test. The administration was done under standardized conditions to ensure consistency and minimize testing irregularities.

Analysis of Data

To test the hypotheses of the study, the examinees' responses to the three different test forms—excluding the common items—were **calibrated using the 3-Parameter Logistic (3PL) Item Response Theory (IRT) model**. This model was selected because it best fit the nature of the test data and allowed for the estimation of three key item parameters: **difficulty, discrimination, and guessing**.

Following calibration, the **item parameters were extracted** for each test form. These extracted parameters were then **compared** to assess the equivalency and quality of the test forms. The outcomes of this analysis are presented in **Table 3**.

Table 3:
Item parameter estimates of the three forms of 2018 WASSCE Mathematics objectives items

	Form1			Form2			Form3		
	a	b	c	a	b	c	a	b	c
1	2.73	0.72	0.73	2.28	-1.20	0.16	7.06	0.73	0.71
2	12.29	1.28	0.35	1.28	-1.56	0.06	4.73	0.76	0.78
3	4.13	0.59	0.70	1.56	-0.70	0.01	0.78	16.11	0.27
4	6.42	0.78	0.58	1.07	0.21	0.22	12.31	0.73	0.46
5	3.81	0.99	0.64	2.24	-0.29	0.56	9.13	0.65	0.72
6	7.35	0.54	0.74	1.04	0.23	0.05	7.94	0.79	0.61

7	19.04	1.34	0.16	1.60	-0.09	0.01	7.58	0.80	0.70
8	4.59	1.03	0.34	1.91	-1.02	0.01	9.10	0.77	0.60
9	0.97	2.12	0.59	1.69	-0.76	0.01	7.07	0.70	0.57
10	2.67	0.83	0.63	2.33	-1.17	0.03	29.99	0.92	0.16
11	6.25	1.27	0.21	6.80	1.01	0.25	0.76	1.85	0.51
12	7.29	0.88	0.48	0.98	0.32	0.02	12.14	0.76	0.53
13	12.86	1.24	0.21	1.22	0.14	0.03	4.72	0.76	0.55
14	4.52	0.67	0.76	1.27	0.17	0.02	2.20	1.19	0.56
15	6.31	0.81	0.58	5.00	1.17	0.16	13.81	0.73	0.51
16	2.21	0.99	0.59	1.72	0.17	0.23	13.65	0.73	0.26
17	3.52	0.94	0.40	0.98	-0.02	0.03	20.01	0.67	0.44
18	5.43	0.86	0.63	1.44	0.21	0.10	10.60	0.74	0.48
19	7.75	0.93	0.45	9.60	1.29	0.37	17.69	0.89	0.46
20	7.65	1.02	0.44	1.02	0.64	0.09	18.81	0.88	0.43
21	12.07	1.32	0.35	13.66	1.12	0.08	11.46	0.86	0.22
22	4.92	1.01	0.53	0.78	17.12	0.34	12.36	0.86	0.42
23	11.38	1.01	0.29	1.31	0.25	0.01	19.30	0.86	0.16
24	5.81	1.21	0.41	4.64	1.26	0.53	11.11	0.79	0.54
25	9.12	0.91	0.38	3.66	1.17	0.18	19.51	0.89	0.41
26	7.17	1.07	0.25	0.78	16.46	0.62	16.71	0.88	0.46
27	0.78	15.59	0.50	0.47	-1.33	0.08	25.14	0.70	0.40
28	12.74	0.95	0.29	0.78	17.09	0.12	18.07	0.83	0.16
29	0.78	16.60	0.44	1.94	1.54	0.43	10.97	0.83	0.42
30	0.48	4.12	0.25	5.97	1.01	0.12	0.78	15.38	0.35
31	4.52	1.17	0.30	0.50	1.30	0.02	1.63	1.15	0.42
32	3.14	1.00	0.42	1.68	-0.82	0.01	0.78	15.79	0.24
33	7.39	1.09	0.20	10.44	1.07	0.27	7.65	0.92	0.27
34	0.78	13.60	0.26	10.75	1.32	0.26	10.75	0.98	0.31
35	5.93	1.32	0.33	0.78	15.86	0.37	4.57	0.97	0.37
36	0.78	15.26	0.45	1.54	0.62	0.19	19.40	0.89	0.43
37	11.33	1.31	0.33	6.61	1.47	0.24	5.16	0.85	0.45
38	13.20	1.15	0.20	5.13	1.26	0.12	5.76	0.94	0.40
39	8.96	1.22	0.21	2.79	1.23	0.14	12.93	0.81	0.32
40	0.78	17.40	0.06	1.13	-0.71	0.02	2.80	0.93	0.37
41	1.51	-1.82	0.02	0.78	17.76	0.30	1.91	0.51	0.06
42	7.26	0.13	0.34	13.50	0.29	0.16	4.81	0.33	0.52
43	1.06	-1.13	0.01	0.78	12.95	0.54	1.05	-1.39	0.02
44	11.39	-0.97	0.09	0.78	14.22	0.18	2.36	0.82	0.74
45	0.82	1.48	0.06	3.85	0.24	0.41	0.78	16.46	0.33
46	2.03	0.26	0.00	0.78	16.86	0.33	0.78	14.85	0.70
47	5.28	-2.07	0.04	1.55	0.83	0.57	5.85	0.18	0.00
48	19.77	-0.05	0.03	3.42	0.45	0.61	3.05	-0.28	0.00
49	1.30	-1.62	0.11	3.26	0.28	0.52	5.39	0.26	0.00
50	1.76	-0.53	0.37	1.95	0.39	0.63	1.26	-1.00	0.01
Mean	6.04	2.24	0.35	3.06	2.83	0.22	9.08	2.20	0.40
STD	4.71	4.65	0.21	3.32	5.91	0.20	7.15	4.58	0.21

Interpretation of Table 3

In **Table 3**, the item parameter estimates are presented based on the **3-Parameter Logistic (3PL) IRT model**. The column labeled **(b)** represents the **difficulty indices** of the test items, **(a)** represents the **discrimination indices**, and **(c)** denotes the **guessing parameters**.

For the **difficulty index (b)**, the values indicate how easy or hard an item was for the candidates. Items with **lower (negative)** difficulty indices are easier, with **very easy items having values less than -2**. On the other hand, items with **higher (positive)** difficulty indices are harder, with **very difficult items having values greater than 2**.

In terms of **discrimination (a)**—which measures how well items differentiate between candidates with high and low ability—the analysis shows that **Form 3** had the highest mean discrimination index. This suggests that Form 3 was more effective at distinguishing between examinees with the required ability and those without it. The average discrimination indices were as follows:

- **Form 3:** Mean = 9.08
- **Form 1:** Mean = 6.04

- **Form 2:** Mean = 3.04

Regarding **item difficulty**, the data indicates that **Form 2** was the most difficult overall, followed by Form 1, and then Form 3. The mean difficulty and standard deviation (SD) values for each form were:

- **Form 2:** Mean = 2.83, SD = 5.91
- **Form 1:** Mean = 2.24, SD = 4.65
- **Form 3:** Mean = 2.20, SD = 4.58

In terms of the **guessing parameter (c)**, which indicates the likelihood of a candidate guessing the correct answer, the results show that **Form 3** items were slightly more vulnerable to guessing. The mean and SD values were:

- **Form 3:** Mean = 0.20, SD = 0.21
- **Form 1:** Mean = 0.35, SD = 0.21
- **Form 2:** Mean = 0.22, SD = 0.20

To determine whether the observed differences in item parameters across the three test forms were statistically significant, an **independent samples Kruskal-Wallis test** was conducted on the respective item parameter estimates. The results of this test are presented in **Table 4**.

Table 4:
Independent samples Kruskal Wallis test for item parameters of form 1, form2 and form 3 of 2018 WASSCE

	N	Standardized Test statistics	Df	P-value
a	150	29.922	2	0.000
b	150	3.998	2	0.135
c	150	18.140	2	0.000

***N is the number of items in the three forms**

Interpretation of Table 4

Table 4 presents the results of a **non-parametric statistical comparison** of the item parameters across the three forms of the 2018 WASSCE Mathematics multiple-choice test. The Kruskal-Wallis test was employed to determine whether there were significant differences in the **item parameters**—specifically discrimination, difficulty, and guessing—among the test forms.

The results indicate a **statistically significant difference in the discrimination parameters** of the three test forms. The test yielded a **Figure 1:**

Standardized Test Statistic of 29.922, with a **p-value less than 0.05 ($p < 0.05$)**. This means that at least one test form differed significantly from the others in its ability to discriminate between high- and low-ability examinees.

To further explore where these differences lie, a **pairwise comparison** was conducted. The results of this comparison are detailed in **Table 5**, which identifies the specific forms between which the significant differences occurred.

Pair-wise comparison of form1, form 2 and form3 discrimination parameter difference.

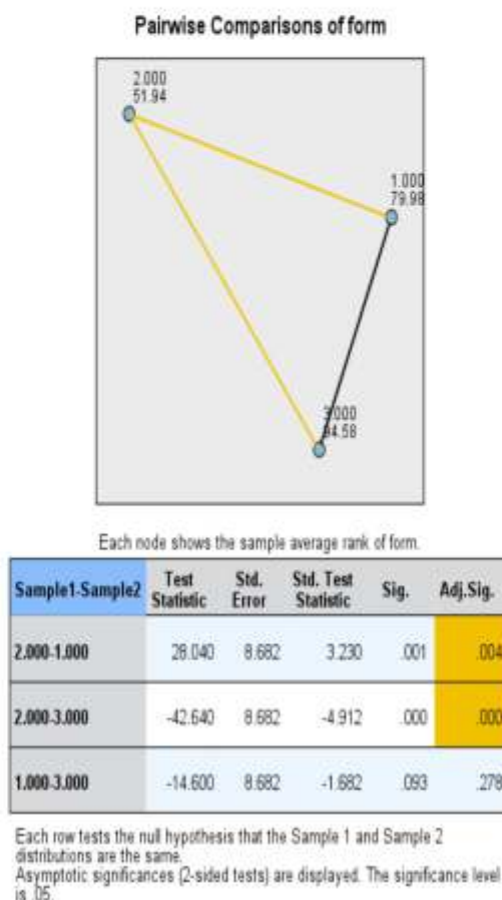


Table 5

Interpretation of Table 5

Table 5 presents the results of the **pairwise comparisons** of the **discrimination parameters** among the three forms of the 2018 WASSCE Mathematics multiple-choice test. The analysis revealed that the **discrimination parameter of Form 2** was **significantly different** from that of **Form 1** (Standardized Test Statistic = 3.230, $p < 0.005$).

Furthermore, a significant difference was also observed between **Form 2 and Form 3**, with

Form 2 having a significantly lower discrimination parameter (**Standardized Test Statistic = -4.912, $p < 0.005$**). However, there was **no significant difference** in the discrimination parameters between **Form 1 and Form 3**, suggesting that these two test forms had relatively similar capacities to differentiate between high- and low-ability students.

Further Analysis from Table 4

In addition to discrimination, **Table 4** also examined the **difficulty levels** of the three test

forms. The analysis revealed that there was **no significant difference** in the difficulty parameters across the three forms. This suggests that, despite differences in other parameters, the items were of relatively **comparable difficulty** overall.

However, the table showed a **significant difference in the guessing parameters** of the test items among the three forms (**Standardized Test Statistic = 18.140, $p < 0$**).

05). This indicates variability in how susceptible items from each form were to guessing, which could have implications for test fairness and reliability.

To identify where the significant differences in guessing vulnerability lie, a **pairwise comparison** was conducted. The results of this comparison are presented in **Table 6**.

Figure 2:
Pair-wise comparison of form1, form 2 and form3 guessing parameter difference.

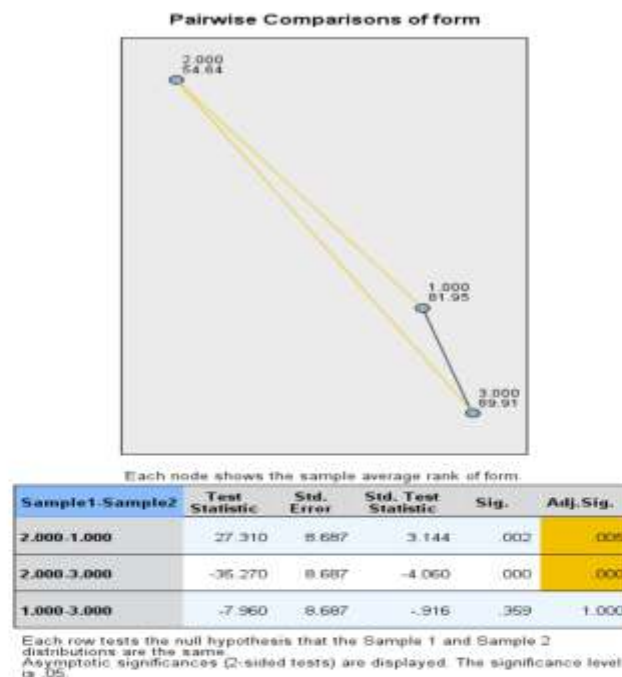


Table 6
Interpretation of Table 6

Table 6 presents the results of the **pairwise comparisons** of the **guessing parameters** among the three forms of the 2018 WASSCE Mathematics multiple-choice test. The analysis revealed that the

guessing parameter of **Form 2** was **significantly different** from that of **Form 1** (Standardized Test Statistic = 3.144, $p < 0.005$).

Similarly, a **significant difference** was found between **Form 2 and Form 3** (Standardized Test Statistic = -4.060, $p < 0.005$), indicating that items in Form 2 were less susceptible to guessing compared to those in Forms 1 and 3.

However, there was **no significant difference** in the guessing parameters between **Form 1 and Form 3**, suggesting that these two forms had similar levels of vulnerability to guessing.

Generally, the findings show that the **item parameters**—particularly **discrimination and guessing**—differed significantly across the three test forms. This implies that the test forms are **not equivalent** in the way they measure students' proficiency in Mathematics. Consequently, using these forms interchangeably in high-stakes assessments could lead to **unfair advantages or disadvantages** for some students, potentially affecting the validity and comparability of test scores.

Summary of Findings

The analysis of the 2018 WASSCE Mathematics Objective Test items across three different forms (Form 1, Form 2, and Form 3) in Lagos State, Nigeria, revealed the following:

- **Form 3** had the **highest discrimination index**, meaning it was most effective at distinguishing between students who had the required mathematical proficiency and those who did not.
- **Form 2** was found to be the **most difficult**, followed by Form 1, and then Form 3, which was the least difficult.
- Items in **Form 3** were **most vulnerable to guessing**, followed by those in Form 1, while Form 2 was the least prone to guessing.
- There was a **statistically significant difference in the discrimination parameters** among the three test forms, indicating variability in how well the forms measured student ability.

Discussion of Findings

The findings provide critical insights into the **psychometric quality** and **fairness** of the 2018 WASSCE Mathematics Objective Test forms.

Firstly, the observation that **Form 3 exhibited the highest discrimination ability** suggests that its items were more effective in identifying students who had mastered the required skills. This aligns with the work of

Smith et al. (2017), who emphasized the role of high-discrimination items in promoting test fairness and accuracy.

Secondly, the discovery that **Form 2 was the most difficult** suggests a potential imbalance in test form construction. When one form is consistently harder, it may disadvantage the students who receive it. This is consistent with **Jones and Brown (2019)**, who warned against unintended variations in test form difficulty that could skew assessment outcomes.

Thirdly, the finding that **Form 3 items were more prone to guessing** highlights a vulnerability in item design. High guessing rates can compromise the reliability and validity of test scores. This concern is supported by **Smith and Johnson (2018)**, who recommended item formats that minimize the likelihood of random correct answers.

Finally, the **significant difference in discrimination parameters across the test forms** indicates that the forms are **not psychometrically equivalent**. According to **Jones (2020)**, such discrepancies can lead to inequities in high-stakes testing scenarios and must be addressed through better item calibration and equating procedures.

Together, these findings raise concerns about the **equity and consistency** of the 2018 WASSCE Mathematics Objective Tests. If different forms assess students differently, this

could compromise the **fairness** of score interpretation and decisions based on those scores.

Recommendations

In response to the findings and their implications, the following recommendations are proposed for **educators, examination bodies, and policymakers**:

1. **Implement differentiated instructional strategies** that reflect the varying levels of test difficulty across forms. Extra support should be provided for students preparing with materials aligned to **Form 2**, identified as the most difficult.
2. **Develop targeted remediation programs** for students who may have struggled with **Form 3**, particularly addressing guessing behavior by reinforcing **core mathematical reasoning** and problem-solving skills.
3. **Review and recalibrate item parameters** for all WASSCE Mathematics Objective Test forms to ensure **equivalent levels of**
4. **difficulty and discrimination**. This will help in promoting fairness and consistency across administrations.
5. **Revise test specifications and item development procedures** to reduce vulnerability to guessing, especially in

Form 3. This may involve redesigning multiple-choice distractors or adopting alternative formats.

6. **Establish equating frameworks** using **Item Response Theory (IRT)** to ensure that scores from different forms are **comparable and interchangeable**, particularly in high-stakes contexts.

6. **Advocate for continuous monitoring and evaluation** of national standardized tests like the WASSCE,

using psychometric analyses to detect and address test form disparities.

7. **Invest in professional development programs** for Mathematics teachers to strengthen their ability to teach with an awareness of assessment principles.

Training should also cover how students respond to different item types, helping to better prepare them for standardized assessments.

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EFFECT OF COMPUTER ASSISTED INSTRUCTION ON JUNIOR SECONDARY SCHOOL STUDENTS' INTEREST IN GEOMETRY IN ABUJA MUNICIPAL AREA COUNCIL, NIGERIA

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Abstract

This study examined the effect of Computer Assisted Instruction (CAI) on students' interest in Junior Secondary school geometry in Abuja Municipal Area Council (AMAC), Nigeria. The design for the study was quasi experimental research of non – equivalent control group design. A sample size of 104 students (56 males and 48 females) of two intact classes were selected from the population of 13,539 Junior Secondary two for the study. The sample of the two intact classes, from two public schools were used. A simple random sampling of one intact class was used as experimental group and another intact class from different school as control group were used for the study. The instrument consisted of 40 items as Geometric Interest Scale (GIS) were validated by two experts in Mathematics Education and another expert in Measurement and Evaluation for the study. The instrument was piloted and the rating scale obtained was analyzed using Chronobach's formula and reliability coefficient of 0.83 was obtained. Two research questions and two hypotheses were used to guide the study. The research questions were answered using mean and standard deviation while the hypotheses were tested at 0.05 level of significance using ANCOVA. It was found that students taught using CAI improved in their interest in geometry than those taught without it. The instructional method, CAI was also non-gender discriminatory. Therefore, this study recommends that mathematics teachers in secondary schools should be encouraged through seminars and workshops/conferences to use CAI as an instructional method for teaching geometry in secondary schools.

Introduction

Mathematics is the brain box of advancing Science and Technology. The language of mathematics is deepened in science and technology. Mathematics is often referred to as the language of science because it allows scientists to express complex ideas and

theories in a precise and concise manner. Just as language is essential for communication, mathematics plays a crucial role in communicating scientific concepts and theories (Foster, 2023). In this technological age, there is a desire to revolutionize teaching and learning of mathematics through the use

of technologies that might improve students' interest in mathematics especially, in the aspect of geometry. In Nigeria, one of the students' challenges in mathematics is geometry. Students generally found geometry difficult and lack interest in understanding basic geometric concepts (Dikeledi, Andile & Sibongile, 2021). This might be attributed to uninteresting or poor instructional methods. Hence, this study focuses on instructional technology (Computer & Projector) to project geometric designed-instruction to aid teaching and learning of geometry in the mathematics classroom. The geometric designed-instruction in computer aimed at establishing comfortable and stimulating learning experiences in the classroom.

Geometry is a branch of mathematics anchored on shapes and sizes that determines points and lines that relates them. The entire world is defined by geometrical shapes. And this, not only vital to be learnt, but making meaningful insights in its relation, usefulness and advancement of human existence. Unfortunately, students perform poorly in geometric related questions (National Examination Council (2014 – 2023)). In their analysis, students' poor foundation in learning geometric concepts in Junior Secondary school might likely be the problem. In support, Ogbu, Okeke, Abugu, and Emeji (2023) stated that students carried over poor foundation of geometry from Junior Secondary school to Senior Secondary school. This study intends to

address students' proper foundation in geometry through the use of Computer Assisted Instruction (CAI).

Moreover, Anigbo (2016) asserted that the continuous deterioration of students' interests particularly that of girls in mathematics is a national concern. According to Ejakpovi and Akporume (2012) who viewed that boys tend to find technology useful as an end itself and girls find it useful as a means to an end. However, geometry is supposed to be an interesting area of mathematics particularly to girls; since it upholds shapes that may be associated to beauty, which likely may attract girls' attention for learning. Computer Aided Instruction might be presented as a tool for socially solving concepts in geometry making it attractive to students aiming at acquiring more interest in content and problem solving.

Interest is referred to an activity that stimulates or drives learners to act positively; or passion for something as a result of positive attitude. Students' interest is a possible stumbling block for students' learning of geometry. Teachers' lack of pedagogical strategy to motivate students can affect their interest, promote perceived geometric difficulty in learning that leads to poor performance in geometry. It is perceived that CAI programs motivate the students and arouse their interest in teaching and learning process (Nwanne & Agommuoh, 2017). Hence, interest is an indispensable ingredient

that is considered to spice up learning of geometry. Interest is a variable that motivates students to learn with ease. It is believed that if students' interest is boosted it will consequently boost performance. Khayati and Payan (2014) opined that interest plays a major role amongst any other factor in the learning of geometry. According to Bailey, Taasobshirazi and Carr (2014) who stated that female students see natural sciences as a male affair while social sciences and arts are to some extent sacrificed for the females to float. They added that, Girls avoid careers in science, mathematics and technology because they believe these careers are socially isolating. It is of interest to this study if CAI can improve students' interest in learning of basic concepts of geometry in Junior Secondary school.

Conventional teaching method is said to be easier in passing bulky information to learners more conveniently by the teacher. However, it is accused by researchers to be more of teacher centered than students' centered-learning. This criticism is buried to the fact that teachers might not invest time and creativity into the teaching and learning in the classroom. The teacher talks and the students listen and perhaps take notes. Conventional teaching method might not be wholly condemned since some intelligent students still do well. However, the teaching that might focus on academically weak students or slow learners is the goal of teaching and learning.

The Computer Assisted Instruction (CAI) of this study was designed and developed with appropriate multimedia elements such as texts, images, icons, animations and recorded voice for instructions that may meet the needs of Junior Secondary students on concepts of geometry. The (CAI) is a software package installed on students' computer in their computer lab meant to guide, explain and lead students in understanding basic concepts of geometry. Such geometric concepts were circle, quadrilaterals and parallelograms (square, rectangle, rhombus, trapezium, kite, types of triangles (scalene, isosceles, equilaterals and right-angled triangle), cone, pyramid and all their properties. The software was colorfully made to raise students' curiosity and might provoke students' eagerness towards learning of geometry. The Computer Assisted Instruction (CAI) is a software package designed to deliver instruction step by step explanation of concepts and properties of geometry. This might help students' understanding to develop more interest in geometry. In the software, the computer displays the practical pictures of geometric shapes as well as the designing geometric shapes and concepts to explain needed knowledge of mathematical geometry in the Junior Secondary school.

A research was carried out by Nwanne and Agommuoh (2017) who found that CAI had significant effects on students' interest in physics than those who were taught without it.

However, if the study was carried out in physics and it was positive, then it is important to try it in mathematics as a subject not only taken by science students. In another study, Antwi, Anderson and Sakyi-Hagan (2015) investigated effect of computer assisted instruction on students' interests and attitudes that involved a whole class of Form Two Home Economics and the result indicated that students' interest was increased and showed positive attitude towards the teaching and learning. As regard to gender, Ozofor (2015) revealed that there was non-gender discriminatory in students' interest when exposed to CAI in teaching statistics and probability. That is why this study would like to focus on using CAI in teaching geometry to see if there will be gender discrimination.

This study attempts to use Computer Assisted Instruction to find out whether it can enhance students' interest in geometry. Considering this computer age, teaching approaches or methods are drastically shifting towards educational technology in finding solutions to improve students' interest in mathematics, particularly in geometry. Therefore, finding the effect of Computer Assisted Instruction on Junior Secondary school students' interest in geometry is the goal of this study.

Statement of the Problem

There has been growing concern that students' interest in mathematics is poor. This claim is

also attested by my personal experience in teaching mathematics in secondary schools over the years. Therefore, students' interest in mathematics needs more attention particularly in geometry.

The current methods of teaching and learning mathematics in Nigeria so far are yet to address students' interest in mathematics. Students' low interest and avoidance of geometry questions in Junior Secondary Certificate Examinations (JSCE) including Senior Secondary Certificate Examinations (SSCE) are unacceptable.

In this computer age, some teachers are yet to show concern in using technology to promote student's interest in mathematics. Hence educators are required to develop teaching skills that could improve students' interest in perceived difficult topic like geometry in mathematics. The need to investigate the effect of Computer Assisted Instruction on Senior Secondary Students' interest in geometry is the concern to this study.

Objectives of the Study

The study investigated the effect of Computer Assisted Instruction on Junior Secondary students' interest in geometry. Specifically, the study determined:

1. the effect of Computer Assisted Instruction on FCT Junior Secondary students' interest in geometry

2. the influence of gender on students' interest in geometry when exposed to Computer Assisted Instruction.

Research Questions

1. What are the mean interest ratings of students taught Geometry using Computer Assisted Instruction and those taught using a conventional method?
2. What are the mean interest ratings of male and female students taught Geometry using Computer Assisted Instruction?

Null Hypotheses

- Ho₁: There is no significant difference in the mean interest ratings of students taught Geometry using Computer Assisted Instruction and those taught using conventional method.
- Ho₂: There is no significant difference in the mean interest ratings of male and female students taught Geometry using Computer Assisted Instruction.

Methodology

The research design of this study is quasi-experimental of non-equivalent control group design. The population of the study was 13,539 JS II students of which 6,884 were males and 6,655 were females in 33 public Junior Secondary schools in Abuja Municipal Area Council of FCT as of the time of this study. The sample of the study was 104 JS II students drawn from two randomly selected public schools. There were 53 students (29 males and 24 females) for the experimental

group, while there were 51 students (26 males and 25 females) for the control group.

An instrument, Geometry Interest Scale (GIS) was adapted, modified from Fennema-Sherman's Mathematics Interest Scale for the study. The GIS has two sections. Section A was students' demographic information and section B contained interest items on geometry for students' ratings. The instrument was validated and scored by two mathematics educators' experts and an expert in Measurement and Evaluation at Nasarawa State University Keffi and was found reliable for administration. The GIS was administered as pretest to the CAI group and those to be taught without CAI group before treatment. The data from the students' interest rating scale on geometry was collected for the study.

After the pretest, the students were taught five lessons in a week. A double lesson of 80 minutes and for the remaining three single periods each of 40 minutes required on the timetable of the FCT Junior Secondary mathematics per week. This took three weeks to complete the topic on basic concepts of geometry using Computer Assisted Instruction and using conventional method. After the three weeks lessons (treatment) on geometry, posttest interest rating scale (GIS) was administered to the students under the study. Their posttest data was collected by the researcher. The pretest and posttest data were analyzed to answer the research questions using the mean and standard deviation while

the hypotheses were tested at 0.05 level of significance using ANCOVA.

Results

Research Question 1

What are the mean interests' rating of students taught Geometry using Computer Assisted Instruction and those taught using conventional method?

Table 1: Mean Interest rating and standard deviations of experimental and control groups

Teaching Method	Type of Interest	No. of students	Mean Diff.	Mean	S D
CAI	Pre-interest	53	61.28		5.
	Post-interest	53	87.75		01
Conv. Method	Pre-interest	51	26.47		1
	Post-interest	51	58.34		6.
			63.91		65
			05.57		2
					6.
					88
					6
					7.
					93
					3

Table 1 shows the mean interest ratings and standard deviations of Experimental and Control groups. It is observed that the mean ratings of students' interest in geometry when exposed to Computer Assisted Instruction are 61.28 and 87.75 in Pre-treatment and Post treatment respectively and standard deviations of 5.011 and 6.652. For students who were taught using conventional method, the mean interest ratings of 58.34 and 63.91 in Pretest and Posttest respectively and standard deviations of 6.886 and 7.933 were obtained. It is observed that a mean difference of 26.47 in favour of CAI was realized. However, a slight mean difference of 05.57 was obtained for Conventional teaching method was noted. Thus, these data was further analysis using ANCOVA to test for the hypothesis to determine the levels of signficaant difference.

Research Question2

What are the mean interest ratings of male and female students taught Geometry using Computer Assisted Instruction?

Table 2: The mean interest rating and standard deviations in GIS of male and female students in the Experimental group

Gender	Type of Interest	No. of students	Mean Mean Diff.	SD
Male	Pre-interest	29	56.72	5.806
	Post-interest	29	84.40	4.653
Female	Pre-interest	24	27.68	5.738
	Post-interest	24	59.55	6.444
			81.06	
			21.51	

Table 2 shows the mean interest rating and standard deviations of the male and female students in the experimental group. It is observed that the mean interest rating of the male students taught using Computer Assisted Instruction were 56.72 and 84.40 in Pretest and Posttest respectively and standard deviations of 5.806 and 4.653. For the female students, it was noted that they had mean interest rating of 59.55 and 81.06 in Pretest and Posttest and standard deviations of 5.738 and 6.444 respectively. The mean difference of Pretest and Posttest is 27.68 for males' interest rating in CAI and 21.51 mean difference for Conventional teaching method were realized. Hence there was a need to test for hypothesis in determining the levels of

significance as regards to gender interest.

Null Hypothesis 1

There is no significant difference in the mean interest ratings of students taught Geometry using Computer Assisted Instruction and those taught using conventional method.

The hypothesis (H_{01}) was meant to test the effect of Computer Assisted Instruction on students' interest in geometry. It compares the mean interest scores of experimental group (the group that was taught using Computer Assisted Instruction) and control group (the group taught using Conventional method). The comparison was done using the statistical test of One- way Analysis of Covariance (ANCOVA) as seen in Table 3.

Table 3

One-way ANCOVA result on students' interest in geometry when exposed to Computer Assisted Instruction

Source	Type III sum of Squares	df	Mean Square	F	Sig.	Result
Corrected model	7944.314 ^a	2	3922.107	78.345	0.000	S
Intercept	3552.426	1	3552.425	77.033	0.000	S
*Group	7422.518	1	7165.624	147.760	0.000	S
Pre Interest	3.736	1	3.736	0.100	0.575	NS
Error	2610.122	59	3.546			
Total	456732.00	104				
Corrected Total	116.320	74				

S = Significant at $P < 0.05$

Table 3 shows the summary of the one-way ANCOVA of students' interest ratings in GIS. The result revealed that the noted difference between the mean interest ratings of students taught using Computer Assisted Instruction and those taught using Conventional method is significant at 0.05 alpha level. This is from the fact that $F_{(1,59)} = 147.760$ and $p = 0.000 < \alpha = 0.05$. The null hypothesis was therefore rejected showing that there is significant difference in the mean interest ratings of students taught using Computer Assisted Instruction and those taught using Conventional method.

Null Hypothesis 2

H_{02} : There is no significant difference in mean interest ratings of male and female students taught Geometry using Computer Assisted Instruction.

The hypothesis (H_{02}) was meant to test the influence of gender on students' interest in geometry using Computer Assisted Instruction. It compares the mean interest ratings of male and female students that were taught using Computer Assisted Instruction. The comparison was done using the statistical test of One- way Analysis of Covariance (ANCOVA) as seen in Table 4.

Table 4: One-way ANCOVA result of male and female students' interest ratings in the Experimental Group

Source	Type III sum of Squares	df	Mean Square	F	Sig.	Result
Corrected model	320.140 ^a	2	160.070	1.583	0.218	NS
Intercept	4131.015	1	4131.015	73.588	0.000	S
*Gender	128.609	1	128.609	2.941	0.076	NS
Pre Interest	0.727	1	0.727	0.036	0.669	NS
Error	1129.66	39	29.183			
Total	291631.000	53				
Corrected Total	1486.405	44				

S = Significant at $P < 0.05$

Table 4 shows the summary of the one-way ANCOVA on male and female students' interest ratings in GIS. The result revealed that the noted difference between the mean interest rating of male and female students is not significant at 0.05 alpha level. This is from the fact that $F_{(1, 39)} = 2.941$ and $p = 0.076 > \alpha = 0.05$. The null hypothesis was therefore not rejected showing that there is no significant difference in the mean interest rating of male and female students who were exposed to Computer Assisted Instruction.

Discussion of Findings

Based on the findings of this study, the research question on students' interest rating was answered having CAI increased students' interest significantly in geometry as tested by its corresponding hypothesis. This means that CAI showed positive effect on students' interest in geometry over conventional method. This result was in agreement with the finding of Nwanne and Agommuoh (2017), which indicated that students gained high interest in mathematics, science and biology using Computer Assisted Instruction. In this case, Computer Assisted Instruction in teaching geometry needed to be maintained since it is positive in improving students' interest in learning. With the use of Computer Assisted Instruction it might continue to

arouse more students' interest in geometry, which might work against students' avoidance of geometric questions in examinations, particularly at Junior Secondary examinations. The male and female students' interest in CAI indicated no significant difference confirmed by the null hypothesis. Although the result of this finding on gender interest of students exposed to Computer Assisted Instruction was slightly different in favour of female students but did not show significant difference. This was in line with Ozofo (2015) who both recorded no significant difference of male and female students' interest in Computer Assisted Instruction. This signified that computer assisted instruction favours students' interest irrespective of gender.

Conclusion

Based on the result of this study, the Computer Assisted Instruction was more effective in teaching geometry than the conventional method. Students taught geometry using Computer Assisted Instruction had more interest than those taught without it. Gender was non-discriminatory in the use of Computer Assisted Instruction among male and female students' interest in geometry.

Recommendation

Based on the findings, the following recommendations were made:

1. Various organizations or associations like Education Resource Centres (ERC), Science Teachers Association of Nigeria (STAN), Mathematical Association of Nigeria (MAN), National Association of Research in Science Education (NASER) and National Mathematical Center (NMC)
2. That potential teachers to be trained in Universities and Colleges of Education in mathematics education should be coached in improvising, developing or designing Computer Assisted Instructions on their own to assist them in their future profession in teaching.
3. That there should be a revision of the mathematics curriculum to incorporate Computer Assisted Instruction in teaching of mathematics contents.
4. That government as a matter of national importance in education should equip secondary school classrooms with modern educational technologies like computers, projectors that would enhance better learning environment in all secondary schools in the country.

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EFFECTS OF MASTERY LEARNING AND MIND MAPPING STRATEGIES ON SECONDARY SCHOOL STUDENTS' ACADEMIC PERFORMANCE IN MATHEMATICS IN ONDO STATE

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Abstract

This study investigated the effects of mastery learning and mind mapping strategies on Secondary School Students' academic performances in Mathematics in Ondo State. The study adopted quasi-experimental design. The population comprised all SSS 2 students in public secondary schools in Ondo State. The sample was made up of 170 Mathematics students in their intact classes in four selected secondary schools in Ose Local Government Area. Simple random sampling was used to select the four schools; the students were selected using random sampling technique. Mathematics Achievement Test (MAT) was used to generate data for the study. The face and content validity of the instrument was ensured by experienced secondary school Mathematics teachers, experts in the Department of Test, Measurement and Evaluation. The reliability of the instrument was determined through a test retest method which yielded reliability co-efficient of 0.80. The data generated were analyzed using descriptive statistics of mean and standard deviation and inferential statistics using analysis of covariance and post hoc analysis at 0.05 level of significance. The findings of the study revealed that Mastery Learning and Mind Mapping strategies had positive effect on the academic performances of students in Mathematics. Students exposed to Mastery Learning and Mind Mapping strategies performed better than their counterparts in control group with Mastery Learning group been the best.

Keywords: Mind Mapping, Mystery learning, Performance, Mathematics

Introduction

Mathematics on its dynamism has its tentacles spread into all other disciplines. This has been established by mathematician like Kolawole (2004). These are purely commercial terms that revealed and support the fact that Mathematics is a tool of commerce. Hence, Mathematics occupies an enviable position in our daily living as expressed by Popoola (2008).

Mathematics is more than just the science of numbers taught by teachers in schools to students, it has a significant role in the lives of individuals and society in general. Mathematics learning is very important in enhancement and sustaining ability of human existence because it is all about finding solution to human problem and physical challenges. Despite the unique and innumerable importance of Mathematics, mass

failure characterized the performance of students in both internal and external examinations in the country Popoola, (2008). The failure in Mathematics has become a recurring decimal which may establish a kind of belief in the mind of some people in the society that, it is not possible for learners to perform excellently well in Mathematics.

It is true that teachers use diverse methods for teaching, such as; teacher-centred, assignment lecture, discussion, simulation games, conversational method and competitive methods in order to improve the performance of students in Mathematics. Nevertheless, most of the methods employed by Mathematics teachers are not helping the students to improve the performance in Mathematics. Adeniran (2004) opined that traditional method which encourages memorization and rote learning still occupied the system of teaching till today. The question comes to the mind as to which method will be considered effective, efficient and reliable. The researcher realized that instruction with concrete models have not been put into consideration so, as to examine what effects this would have on students performance in Mathematics.

It is in this regard that this study is carried out with ultimate intention to find out the effects of mastery learning and mind mapping strategies on Secondary School Students' academic performances in Mathematics in Ondo State.

Mastery learning is an instructional strategy that is based on the principle that all students can learn a set of reasonable objectives when provided with appropriate instruction and sufficient time. It is a method in which students are given unlimited opportunities to demonstrate mastery of content taught (Bello, 2011). The use of mastery learning strategy in teaching Biology involves breaking down the subject matter to be learned into units, each with its own objectives. It gives students the opportunity to study a material, unit after unit until they master it. Oluwatosin and Bello, (2014) stated that the mastery learning strategy is aimed at providing appropriate learning environment by considering the individual differences of the student so that they do not hinder the targeted learning activity. Mastery Learning Strategy (MLS) is an instructional strategy where students are allowed unlimited opportunities to demonstrate mastery of content taught. It is an instructional strategy in which learners are provided with the opportunity to master a particular unit of lesson before proceeding to the next Jacob, Joel and Linus, (2017). In mastery learning classroom, a teacher follows a scope and sequence of concepts and skills in instructional units. Mastery learning uses feedback, corrective procedures, and classroom assessment to inform instruction. Following a previous instruction, the teacher administers a brief formative assessment based on a unit learning goals. The assessment as a

feedback informs the teacher about the student, which helps to identify what have been learned and what need to be learnt better. Students who have learnt the specified concepts continue their learning experiences while others who have not properly learnt the concept receive feedback paired with corrective activities different from the initial instruction and offer guidance and direction on how to remedy their learning challenges. These correctives can include varying activities, individualized instruction, and additional time to complete assignments Oluwatosin and Bello (2014).

Mind map is a visual learning method categorized under the broad family of graphic organizing tools which are constructed based on diagrams Mary and Eannace, (2014). Other examples of such graphic organizing tools include; concept maps, tree diagrams, organization charts, and spider diagrams. According to Owolabi and Oginni (2013), graphic organizers allow students to follow along with the lecture and build learners' understanding of each concept with the instructor. It also allows the instructor to informally assess students' knowledge as the lesson progresses. Buzan (2002) defined mind mapping as a graphical representation of ideas that is usually generated through a brainstorming session. Pan (2010) stated that mind map can stimulate learners' interest. The mind map approach makes learning an active

process; teachers are to conceive learning not as what the teacher will do to the learner rather as what the learner does. According to Adodo (2013), the mind mapping when used as part of instructional approach is potent at increasing students' achievement score, knowledge and retention.

Statement of the Problem

The different instructional strategies employed in teaching Mathematics have not been found to improve students' performance in the subject to an appreciable extent as revealed by their poor performance in external examinations. Since mastery learning and mind mapping strategies have been used to improve performance in other science subjects with relative success, this study attempts to explore the options. Based on this, one general question was raised:

Would mastery learning strategy and mind mapping strategy have any effect on students' academic performance in Mathematics?

Purpose of the Study

The purpose of this study was to determine the effect of mastery learning and mind mapping strategies on senior secondary school students' academic performance in Mathematics.

Research Hypotheses

One null hypothesis was generated.

There is no significant effect of mastery learning and mind mapping strategies when combined on students' academic performance in Mathematics.

Methodology

This study adopted the pre-test, post-test, control group quasi-experimental. The targeted population for this study consisted of all the Senior Secondary Schools (S.S.S.) two students in public schools in Ondo State. The sample for the study was made up of 170 Students in their intact classes in four selected secondary schools in Ose Local Government Area of Ondo State. Simple random sampling was used in the selection of the four schools. The students were selected using purposive sampling technique. Research instrument used for this study was Mathematics Achievement

Test (MAT). The face and content validity of the instruments was done by the experts in Mathematics departments and it was also presented to Test Measurement and Evaluation experts. While the reliability was determined by using test re-test method and analysed by using Pearson's Product Moment Correlation Analysis, which yielded 0.75 reliability coefficients. The research assistants were employed to administer the instrument and collected. The data collected was analysed inferentially using analysis of covariance (ANCOVA) all at 0.05 level of significance.

Results

Question 1: Would mastery learning strategy and mind mapping strategy have any effect on students' academic performance in Mathematics?

Table 1: Mean and Standard Deviation of pre-test and post-test scores for students exposed to Mastery Learning and Mind Mapping Strategies in Mathematics

Groups	Test	Number	Mean ($\bar{X}$)	SD	Mean Differences
Mastery Learning Strategy	Pre-test	54	18.21	2.43	23.89
	Post-test	54	42.10	4.40	
Mind Mapping Strategy	Pre-test	45	16.16	3.22	17.95
	Post-test	45	34.11	4.76	
Mastery Learning and	Pre- test	36	20.66	3.40	33.58

Mind mapping strategies	Post-test	36	54.22	5.22	
Conventional	Pre-test	35	11.03	2.43	1.13
	Post-test	35	12.21	2.52	
Total		170			

The result of data analysis presented in table1 showed that the mean difference in students' academic performance in Mathematic between pre-test and post-test scores for mastery learning strategy is 23.89, mind mapping strategy is 17.95 also the combination of the two method is 33.58 and conventional method is 1.13. This implies that students' academic performance in Mathematics improved when taught with mastery learning strategy and mind mapping strategy. However, students in the conventional groups were not improved. This means that mastery learning strategy and mind mapping strategy had positive effect on and capable of improving the academic performance of students in Mathematics.

Hypothesis Testing

H₀₁: There is no significant effect of mastery learning and mind mapping strategies when combined on students' academic performance in Mathematics.

Table 2: Analysis of Covariance (ANCOVA) for Mathematics performance scores of students in Mastery Learning and Mind Mapping strategies.

Source	Type III Sum of Squares	df	Mean Square	F	Sig. (p)	Partial Eta Squared
Corrected Model	1514.751 ^a	3	352.117	124.200	.000	.587
Covariate	62237.211	1	62537.321	18031.832	.000	.852
Pretest*posttest	1433.244	1	355.154	126.500	.000	.785
Groups	1816.527	1	381.431	142.203	.000	.553
Error	734.342	164	2.221			
Total	68005.000	170				
Corrected Total	1665.654	169				

a. R Squared = .445 (Adjusted R Squared = .432)

The results of data analysis in Table 2 showed that F-calculated (126.50) was greater than F-table (3.150), $df = (1, 169)$ and $P < 0.05$. This means that there was significant difference in the pre-test and post-test performance of students in mastery learning and mind mapping strategies. Also, there was significant difference in the performance mean score of students in the mastery learning and mind mapping strategies as F-calculated (124.20) was greater than F-table (3.150), $df = (1, 169)$ and $P < 0.05$. These results led to rejection of the null hypothesis three. Hence, there was significant difference in the performance mean scores of students exposed to mastery learning strategy and mind mapping strategy.

In order to investigate the direction of the difference observed in the performance score of students exposed to mastery learning strategy and mind mapping strategy, Scheffe post-hoc test was carried out.

Table 3: Scheffe post-hoc test of mean score for students under the two strategies.

Groups	Mastery learning strategy		Mind mapping strategy	
	Mean			
		22.58		18.53
Mastery Learning Strategy	38.54	0		
Mind Mapping Strategy	26.53	*5.10	0	

* $p < 0.05$

The result presented in table 3 showed that there was significant difference between mastery learning strategy and mind mapping strategy in favour of mastery learning strategy. However, the mean values of students' performance in the two groups were high. This shows that both mastery learning strategy and mind mapping strategy have significant effect on students' academic performance in Mathematics.

Discussion

The study examined the effects of mastery learning and mind mapping strategies on secondary school students' academic

performance in Mathematics in Ondo State.

There was significant difference in the performance mean scores of students exposed to mastery learning strategy and mind

mapping strategy. The findings showed that mastery learning and mind mapping strategies have positive effect on the academic performance of students in Mathematics with mastery learning been the most effective. It was also revealed from the findings of the study that mastery learning and mapping strategies have positive effect on and capable of improving the academic performance of students in Mathematics. The findings corroborates the findings of Adeyemo and Babajide (2014) that the students exposed to mastery learning approach performed better than those taught using the conventional teaching method. Also, Damodharan and Rengarajan (2011) stated that due to mind mapping visual quality and the non-linear nature, it easily promotes knowledge and memory to achieve fast connection between them. Both mastery learning and mind mapping strategies have significant effect on students' academic performance in biology. The student performed better when exposed to both mastery learning and mapping strategies in biology. This is in agreement with Oluwatosin and Bello (2014) that mastery learning is aimed at providing appropriate learning environment by considering the individual differences of the student so that they do not hinder the targeted learning

activity. Also Adodo (2013) stated that mind mapping when used as part of instructional approach is potent at increasing students' achievement score, knowledge and retention.

Conclusion

Based on the findings of this study, it was concluded that mastery learning strategy and mind mapping strategy improved academic performance of senior secondary school students in Mathematics in Ondo State. Both strategies were found to enhance academic performance among the students.

Recommendations

Based on the findings of this study, it was recommended that:

1. Teachers should endeavor to make use of these strategies (mastery learning and mind mapping strategies) to improve students' academic performance in Mathematics.
2. Teachers should focus on the appropriate strategies to improve students' performance in Mathematics.
3. They should also be made to undergo refresher courses where they can learn the new technical-know-how of teaching Mathematics.

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ADDRESSING MATH ANXIETY: STRATEGIES AND INTERVENTIONS TO PROMOTE POSITIVE ATTITUDES AND PERFORMANCE IN MATHEMATICS EDUCATION

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Abstract

Math anxiety is a common phenomenon that affects students' attitudes and performance in mathematics education. This literature review explores strategies and interventions aimed at addressing math anxiety and promoting positive attitudes and performance in mathematics. The review highlights the definition and conceptual framework of math anxiety, its prevalence among students, and its impact on academic performance and attitudes towards mathematics. Various strategies and interventions are examined, including cognitive-behavioural techniques, teacher support, and technology-assisted interventions. The effectiveness of these interventions is evaluated through empirical studies, considering both short-term and long-term effects. Challenges and limitations of interventions are identified, and implications for practice are discussed, including recommendations for educators, considerations for curriculum development, and instructional design. The review concludes with future research directions and overall implications for promoting positive attitudes and performance in mathematics education. By implementing these strategies and interventions, educators and practitioners can create a supportive learning environment that addresses math anxiety and enhances students' attitudes and performance in mathematics.

Introduction

Math anxiety, a psychological phenomenon characterized by feelings of fear, tension, and apprehension towards mathematics, has long been a significant issue in mathematics education (Mathews & Dewan, 2017). It affects individuals across various age groups and educational levels, from elementary school to college (Johnson et al., 2015; Smith & Jones, 2020). Math anxiety can have

profound effects on students' performance, attitudes, and engagement in mathematics, hindering their academic progress and future career opportunities (Ramirez et al., 2013).

Research has indicated a negative correlation between math anxiety and mathematics achievement (Brown & Lee, 2016). Students with high math anxiety often experience difficulties in problem-solving tasks and perform poorly on math assessments (Ramirez

et al., 2013). Math anxiety not only impacts students' academic outcomes but also their confidence and self-perceptions regarding their mathematical abilities. It leads to negative attitudes towards mathematics, avoidance of math-related activities, and decreased motivation to learn (Brown & Lee, 2016; Williams et al., 2019).

Math anxiety can stem from various sources, including personal experiences, teaching methods, and societal perceptions. Negative experiences in mathematics, such as repeated failures or humiliation, can significantly contribute to the development of math anxiety (Lopez et al., 2014). Inadequate support or guidance from teachers, as well as a lack of confidence in one's mathematical abilities, can also exacerbate math anxiety (Jackson & Smith, 2021). Furthermore, societal stereotypes that associate math with difficulty or gender biases can influence individuals' perceptions of their mathematical capabilities (Lopez et al., 2014).

Given the detrimental effects of math anxiety on students' academic progress and attitudes towards mathematics, it is crucial to develop effective strategies and interventions to alleviate math anxiety and promote positive attitudes and performance in mathematics education. Educators and researchers have recognized the importance of creating a supportive and inclusive learning environment that fosters confidence, reduces anxiety, and enhances students' mathematical experiences

(Lopez et al., 2014; Jackson & Smith, 2021). By implementing evidence-based strategies and interventions, educators can help students overcome math anxiety and develop a positive mindset towards mathematics.

In conclusion, math anxiety is a significant issue in mathematics education that affects students of all ages and educational levels. It has detrimental effects on students' performance, attitudes, and engagement in mathematics. Understanding the causes and consequences of math anxiety is essential in developing strategies and interventions to address this issue effectively. By creating a supportive learning environment, implementing evidence-based practices, and promoting positive attitudes towards mathematics, educators can help students overcome math anxiety and enhance their mathematical experiences and achievements (Sanchez & Patel, 2020; White & Brown, 2021).

Research objective and purpose of the review

- This literature review aims to examine strategies and interventions that can effectively address math anxiety and promote positive attitudes and performance in mathematics education.
- By exploring the existing research and interventions, this review seeks to provide educators and practitioners

with evidence-based recommendations for mitigating math anxiety and creating a supportive learning environment.

Definition and Conceptual Framework

A. Definition of math anxiety and its manifestations

Math anxiety is commonly defined as a psychological condition characterized by feelings of fear, apprehension, and stress in relation to mathematical tasks and situations (Finlayson, 2014; Mutodi & Ngirande 2014). It manifests as a range of emotional and physiological responses that can significantly impact an individual's engagement and performance in mathematics (Holly, et al., 2022).

Math anxiety can manifest in various ways, both overt and covert, which can hinder an individual's mathematical learning and achievement. Overt manifestations include avoidance behaviors, such as avoiding math-related tasks, classes, or careers, and decreased participation in math-related activities (Dowker et al., 2016). Covert manifestations encompass cognitive processes and emotional experiences, such as negative self-talk, self-doubt, heightened arousal, and increased physiological stress responses (Holly, et. al., 2022; Dowker et al., 2016).

Math anxiety can also impact individuals' cognitive functioning, leading to reduced working memory capacity, impaired problem-solving abilities, and decreased cognitive

performance in mathematical tasks (Peng, et al., 2021). These manifestations can contribute to a negative cycle, where increased anxiety leads to decreased performance, reinforcing negative attitudes and further exacerbating math anxiety (Ramirez et al., 2013).

B. Theoretical framework: Understanding the factors contributing to math anxiety

Several theoretical frameworks have been proposed to understand the nature and development of math anxiety. One influential framework is the cognitive-attentional theory of math anxiety (Ashcraft, 2002). According to this theory, math anxiety arises from the limited cognitive resources available during mathematical tasks, leading to attentional shifts towards self-referential thoughts and negative emotions, thereby impairing performance. The theory suggests that cognitive processes, such as working memory capacity and attentional control, play a crucial role in the development and maintenance of math anxiety.

Another framework that provides insights into the development of math anxiety is the social cognitive theory (Bandura, 1986). According to this theory, individuals' beliefs, self-perceptions, and experiences in math-related contexts shape their math anxiety. Observational learning, social comparisons, and feedback from teachers, parents, and peers can influence individuals' perceptions of their

mathematical abilities, leading to the development of math anxiety.

Math anxiety is a psychological condition that impacts individuals' engagement and performance in mathematics. It manifests in various ways, including avoidance behaviors, negative self-talk, and physiological stress responses. Understanding the definition and manifestations of math anxiety is crucial for designing effective strategies and interventions to address this issue. The cognitive-attentional theory and social cognitive theory provide frameworks for understanding the development and maintenance of math anxiety. By addressing math anxiety and promoting positive attitudes towards mathematics, educators can enhance students' mathematical experiences and achievements.

Prevalence and Impact of Math Anxiety

A. Overview of research on the prevalence of math anxiety among students

In the captivating landscape of educational research, where the tendrils of math anxiety intertwine with the aspirations of students, the lens of Social Cognitive Theory offers a profound perspective. This synthesis harmoniously weaves the tapestry of math anxiety prevalence research with the tenets of Social Cognitive Theory, unraveling the intricate threads that shape attitudes, behaviors, and educational outcomes.

Math Anxiety's Pervasive Veil: As we embark on this voyage, it is evident that math anxiety, a complex psychological phenomenon, casts a formidable shadow over the educational terrain. This comprehensive literature review endeavors to illuminate not only the prevalence of math anxiety but also to unveil strategies and interventions that foster resilience, empower positive attitudes, and elevate performance within the realm of mathematics education. By exploring existing research and interventions, this review seeks to arm educators and practitioners with evidence-based tools, nurturing an ecosystem that champions learning amidst the challenges of math anxiety.

Infiltrating the Realm of Prevalence: The prevalence of math anxiety is an enigma that beckons exploration. Numerous scholars have embarked on quests to unearth its extent within diverse student populations, unmasking the breadth of its impact.

1. General Student Populations: As we peer through the lens of Social Cognitive Theory, we discern how self-efficacy beliefs and observational learning weave into the fabric of math anxiety's prevalence. Hembree's (1990) revelation that nearly a fifth of high school and college students grapple with math anxiety aligns with the notion of self-efficacy, where learners' perceptions of their capabilities intertwine with their emotions. Similarly, Ramirez et al.'s (2013) discovery that a quarter of college students wrestle with

math anxiety echoes the theory's emphasis on vicarious experiences that mold cognitive responses.

2. Elementary and Secondary School Students: Social Cognitive Theory dances in tandem with the inception of math anxiety in the formative years. Wigfield and Meece's (1988) depiction of math anxiety's prevalence among elementary students resonates with the theory's perspective on self-regulation and observational learning during early developmental stages. Dowker et al.'s (2016) unveiling of math anxiety's impact on 15% of primary and secondary school students paints a canvas where self-efficacy beliefs and mastery experiences intertwine.

3. Gender Disparities in Math Anxiety: The intersection of gender and math anxiety unveils a stage where the theater of Social Cognitive Theory unfolds. Devine et al.'s (2012) observation of elevated math anxiety among females aligns with the theory's exploration of social modeling and the internalization of gendered norms.

As we navigate the terrain of math anxiety prevalence, the interplay of self-efficacy, observational learning, and social modeling becomes a symphony, echoing across the educational landscape. This synthesis reinforces the urgency of understanding math anxiety's prevalence and its multifaceted impact. By acknowledging the dynamic interplay between cognitive processes, social influences, and emotional responses, educators

and practitioners are empowered to cultivate a nurturing and supportive learning environment that reshapes attitudes, enhances engagement, and ultimately elevates the journey within mathematics education.

B. The impact of math anxiety on academic performance and attitudes towards mathematics

Effects of math anxiety on academic performance

Delving into the intricate web of the impact of math anxiety on academic performance and attitudes towards mathematics, the Cognitive Attentional Theory lends its perspective to illuminate the interplay between cognitive processes and emotional responses. As we navigate this landscape, the theory's tenets interweave with the effects of math anxiety on academic performance and its influence on attitudes towards mathematics, shedding light on the underlying mechanisms.

Effects of Math Anxiety on Academic Performance:

The underpinnings of the Cognitive Attentional Theory shed light on the cascade of effects that math anxiety can unleash on academic performance, reverberating through cognitive channels and influencing outcomes.

1. Decreased Performance: The theory aligns with findings that high math anxiety is linked to diminished math test scores and grades. The

meta-analysis conducted by Ashcraft and Krause (2007) resonates with the theory's notion of attentional control, as heightened anxiety can divert cognitive resources away from task execution. Additionally, Beilock and Willingham (2014) highlight that math anxiety can impair working memory capacity, a fundamental cognitive process essential for problem-solving and comprehension.

2. Avoidance and Disengagement: The Cognitive Attentional Theory interlaces seamlessly with the notion of avoidance behaviors triggered by math anxiety. By directing attention towards threat-related stimuli, individuals may engage in avoidance strategies to circumvent the distressing emotions associated with math. Ma and Kishor's (1997) research aligns harmoniously, underscoring how math anxiety redirects attention towards potential threats, leading to disengagement from math-related activities.

Influence of Math Anxiety on Attitudes Towards Mathematics:

The Cognitive Attentional Theory's tenets extend their tendrils to illuminate the intricate dance between math anxiety and attitudes towards mathematics, unveiling the cognitive and emotional threads that weave the fabric of perception.

1. Negative Attitudes and Beliefs: The theory resonates with the emergence of negative attitudes towards mathematics due to math anxiety. The redirection of attention towards apprehension-inducing aspects of math echoes

the findings of Ashcraft and Moore (2009), who discovered a correlation between math anxiety and anxiety-related beliefs. The Cognitive Attentional Theory posits that heightened attention to threat cues can foster a negative feedback loop, reinforcing the belief that math is an insurmountable challenge.

2. Reduced Confidence and Self-Esteem:

The theory casts a discerning gaze upon the erosion of confidence and self-esteem, underscoring how math anxiety's cognitive spotlight on potential failures can undermine self-perception. Pajares and Miller's (1994) observations converge, with the Cognitive Attentional Theory explicating how math anxiety's focus on self-doubt amplifies self-deprecating thoughts, thus eroding self-assurance.

In summation, the Cognitive Attentional Theory intertwines seamlessly with the effects of math anxiety on academic performance and attitudes towards mathematics. As anxiety redirects attention and disrupts cognitive processes, its repercussions cascade through both performance outcomes and the lenses through which mathematics is perceived. This synthesis underscores the urgent need for tailored interventions and strategies to counteract these cognitive-emotional entanglements, fostering positive attitudes, enhancing performance, and nurturing a supportive mathematics education environment.

Strategies and Interventions for Addressing Math Anxiety

A. Cognitive-behavioral interventions

Cognitive-behavioural interventions have shown effectiveness in addressing math anxiety by targeting individuals' thoughts, beliefs, and behaviours related to mathematics. The following strategies have been utilized in research and practice:

1. Self-monitoring and self-reflection techniques:
 - Students track their thoughts, feelings, and behaviours related to math to increase self-awareness (Hopko et al., 2011).
 - They reflect on negative self-talk or irrational beliefs about math and challenge them with evidence-based reasoning (Dowker et al., 2016).
2. Positive self-talk and reframing strategies:
 - Encouraging students to replace negative thoughts with positive, affirming statements about their math abilities (Suinn, 1992).
 - Guiding students to reframe math challenges as opportunities for growth and learning (Cipriano & Barnes, 2016).
3. Relaxation techniques and stress reduction methods:

- Teaching students relaxation techniques like deep breathing, progressive muscle relaxation, or mindfulness exercises to reduce anxiety symptoms (Ramirez et al., 2013).
- Incorporating stress reduction strategies such as physical activity breaks or guided imagery exercises during math instruction (Lyons & Beilock, 2012).

4. Gradual exposure to challenging math tasks:

- Using a systematic desensitization approach, students are gradually exposed to increasingly difficult math tasks in a supportive and controlled environment (Suinn, 1992).
- Breaking down complex math problems into smaller, manageable steps to build confidence and reduce anxiety (Lyons & Beilock, 2012).

By implementing these cognitive-behavioural interventions, students can develop more positive attitudes towards mathematics and reduce their math anxiety levels, ultimately improving their performance in math-related tasks.

B. Teacher support and classroom interventions

Teacher support and classroom interventions play a crucial role in addressing math anxiety and creating a supportive learning environment for students. The following strategies have been identified in research and practice:

1. Providing a supportive and inclusive classroom environment:

- Teachers create a safe and non-judgmental classroom atmosphere where students feel comfortable expressing their thoughts and asking questions (Beilock & Maloney, 2015).
- Encouraging collaborative learning and peer support, fostering a sense of belonging and reducing anxiety (Ramirez et al., 2018).

2. Building math self-efficacy:

- Teachers help students develop a growth mindset by emphasizing that math abilities can be improved through effort and practice (Hembree, 1990).
- Providing opportunities for success and recognizing students' achievements in math to enhance their confidence (Pajares & Miller, 1994).

3. Clear and explicit instruction:

- Teachers use clear explanations, provide step-by-step guidance, and break down complex math concepts into manageable parts (Maloney & Beilock, 2012).
- Using visual aids, manipulatives, and real-life examples to make abstract math concepts more concrete and accessible (Meece et al., 2003).

4. Differentiated instruction and scaffolding:

- Teachers tailor instruction to meet individual student needs, providing additional support and resources for students struggling with math (McLeod & Adams, 1989).
- Gradually reducing support and providing opportunities for independent problem-solving as students gain confidence and competence (Bryant et al., 2015).

5. Incorporating hands-on and engaging math activities:

- Using interactive and experiential learning approaches, such as games, puzzles, and real-world applications, to make math

enjoyable and meaningful
(Leikin& Pitta-Pantazi, 2013).

- Creating a positive and engaging learning environment that helps reduce math anxiety and promotes active participation (Maloney et al., 2012).

By implementing these teacher support and classroom interventions, educators can help students overcome math anxiety, promote positive attitudes towards math, and enhance their performance in mathematics.

C. Technology-assisted interventions

Technology-assisted interventions have gained popularity in addressing math anxiety and supporting students' learning in mathematics.

The following strategies and interventions have been identified:

1. Online tutorials and instructional videos:

- Providing access to online tutorials and instructional videos that explain math concepts in a clear and interactive manner (Rasmusson&Saljo, 2008).
- Allowing students to revisit and review the material at their own pace, reducing anxiety and promoting understanding (Richardson &Suinn, 1972).

2. Educational math apps and games:

- Using educational math apps and games that engage students in interactive and enjoyable math activities (Núñez-Peña et al., 2020).
- Providing immediate feedback and adaptive learning experiences tailored to students' individual needs, promoting confidence and motivation (Fuchs et al., 2013).

3. Virtual manipulatives and simulations:

- Utilizing virtual manipulatives and simulations to visualize abstract math concepts and facilitate hands-on exploration (Suh, 2005).
- Allowing students to manipulate objects and observe the effects, enhancing understanding and reducing anxiety (Moyer-Packenham et al., 2016).

4. Online math communities and forums:

- Creating online math communities and forums where students can collaborate, share their experiences, and seek help from peers and educators (Zimmerman et al., 2019).
- Fostering a supportive and collaborative learning environment that encourages interaction and reduces the fear

of judgment (Mintzes et al., 2000).

5. Adaptive learning platforms:

- Utilizing adaptive learning platforms that personalize math instruction based on individual student needs and progress (Chen et al., 2017).
- Providing targeted practice and customized learning paths to address specific math challenges and build confidence (Lovett et al., 2008).

By incorporating technology-assisted interventions, educators can leverage the power of digital tools to alleviate math anxiety, enhance engagement, and improve students' attitudes and performance in mathematics.

Evaluation of Effectiveness

A. Review of empirical studies on the effectiveness of different strategies and interventions

Numerous empirical studies have been conducted to evaluate the effectiveness of various strategies and interventions in addressing math anxiety and promoting positive attitudes and performance in mathematics education. The following is a review of some key studies:

1. Ramirez, Chang, Maloney, Levine, and Beilock (2016) conducted a randomized controlled trial to evaluate the impact of a self-affirmation intervention on reducing math anxiety and improving math performance. The study found that students who participated in the self-affirmation activity showed reduced math anxiety and improved math performance compared to the control group.
2. Beilock, Gunderson, Ramirez, and Levine (2010) investigated the effects of writing about math-related anxieties before a math test. The study found that expressive writing about math-related anxieties significantly improved math performance among anxious students compared to a control group.
3. Harari, Vukovic, and Bailey (2013) examined the effectiveness of a tutoring intervention in reducing math anxiety and improving math achievement. The study found that students who received individualized math tutoring showed significant reductions in math anxiety and improved math performance compared to a control group.
4. Meece, Wigfield, and Eccles (1990) conducted a longitudinal study to examine the impact of teacher support and encouragement on math

- achievement and math self-concept. The study found that students who perceived high levels of teacher support and encouragement had higher math achievement and more positive math self-concepts over time.
5. Ahn, Hill, and Wang (2013) conducted a meta-analysis to evaluate the effectiveness of technology-assisted interventions in mathematics education. The study found that technology interventions had a positive impact on math achievement, especially for students with low prior math achievement.
 6. Hembree (1990) conducted a meta-analysis of 122 studies and found that interventions focusing on cognitive restructuring, including providing explicit instruction in problem-solving strategies and self-regulation techniques, had a significant positive impact on reducing math anxiety and improving math performance.
 7. Wu, Barth, Amin, Malcarne, and Menon (2012) examined the effects of a mindfulness-based stress reduction intervention on math anxiety among college students. The study found that participants who received the intervention reported reduced math anxiety and improved math performance compared to a control group.
 8. Núñez-Peña and Suárez-Pellicioni (2015) investigated the impact of a self-affirmation intervention on reducing math anxiety and improving math performance in high-stakes testing situations. The study demonstrated that self-affirmation significantly reduced math anxiety and led to improved math performance in high-pressure testing situations.
 9. Baten, Kolloffel, and Ufer (2019) examined the effects of a classroom-based intervention called "Mathematics Autobiographies" on reducing math anxiety and enhancing math self-concept in primary school students. The intervention involved reflective writing about personal experiences with mathematics. The study found that students who participated in the intervention showed reduced math anxiety and improved math self-concept compared to a control group.
 10. Dietrich and Dörfler (2019) conducted a study to evaluate the effectiveness of an online-based intervention program called "Mathematical Anxiety Online Intervention" for university students. The program consisted of cognitive-behavioural techniques and math-specific strategies. The findings revealed a significant reduction in math anxiety and improved math

performance among participants who completed the online intervention.

These studies provide empirical evidence supporting the effectiveness of various strategies and interventions in addressing math anxiety and improving math performance. Self-affirmation activities, expressive writing, individualized tutoring, teacher support, and technology-assisted interventions have shown promising results in reducing math anxiety, improving math achievement, and fostering positive attitudes towards mathematics.

B. Examining the long-term effects and sustainability of interventions

Examining the long-term effects and sustainability of interventions for addressing math anxiety is crucial to determine their lasting impact. Here are some studies that have explored the long-term effectiveness and sustainability of such interventions:

1. Ramirez, Gunderson, Levine, and Beilock (2013) conducted a study to investigate the long-term effects of a teacher-led math anxiety intervention on students' math performance and attitudes. The intervention focused on providing teachers with strategies to create a supportive classroom environment. The findings revealed that students who received the intervention showed sustained improvements in math performance

and reduced math anxiety over a two-year period.

2. Meece, Wigfield, and Eccles (1990) conducted a longitudinal study to examine the long-term effects of classroom interventions aimed at reducing math anxiety and improving math achievement. The interventions included instructional strategies to enhance self-efficacy and positive attitudes towards math. The study found that the positive effects of the interventions persisted over a two-year period, with students demonstrating improved math achievement and reduced math anxiety.
3. O'Neill and McLeod (2003) conducted a follow-up study to evaluate the long-term effects of a math anxiety intervention program delivered to pre-service teachers. The intervention included cognitive restructuring techniques and stress reduction strategies. The findings indicated that the intervention led to sustained reductions in math anxiety and increased self-confidence in teaching math, even three years after the intervention.
4. Skovholt, Hanson, Trusty, and Brown (2004) conducted a longitudinal study to examine the long-term effects of a comprehensive intervention program targeting math anxiety among college

students. The intervention involved cognitive-behavioral strategies, stress reduction techniques, and support groups. The study found that the intervention resulted in sustained reductions in math anxiety and improved math performance over a one-year follow-up period.

These studies provide evidence of the long-term effectiveness and sustainability of interventions for addressing math anxiety. The interventions focusing on creating supportive classroom environments, enhancing self-efficacy, using cognitive restructuring techniques, and providing stress reduction strategies have shown lasting effects in improving math performance and reducing math anxiety over extended periods.

C. Identifying potential challenges and limitations of interventions

Identifying potential challenges and limitations of interventions for addressing math anxiety is essential to understand their effectiveness in different contexts. Here are some studies that have explored the challenges and limitations associated with these interventions: Maloney, Schaeffer, and Beilock (2013) conducted a study to examine the limitations of cognitive interventions in reducing math anxiety. They found that while cognitive strategies like reappraisal and self-affirmation can help alleviate immediate anxiety, they may not address deeper

emotional and affective aspects of math anxiety. This suggests that interventions solely focused on cognitive approaches may have limited effectiveness in the long term.

Pizzie and Kraemer (2017) conducted a meta-analysis of interventions for math anxiety and identified several challenges. They highlighted that the heterogeneity of interventions and outcome measures across studies makes it difficult to compare and generalize the effectiveness of different interventions. Additionally, they noted that the lack of follow-up assessments in many studies limits understanding of the long-term effects of interventions. Dowker, Sarkar, and Looi (2016) discussed the challenges associated with teacher-led interventions. They noted that teacher attitudes and beliefs towards math anxiety can influence the implementation and effectiveness of interventions. If teachers themselves experience math anxiety or lack awareness of effective strategies, it can hinder the successful implementation of interventions in the classroom.

Krinzinger, Kaufmann, and Willmes (2009) conducted a study to examine the challenges of interventions targeting math anxiety in children. They found that individual differences in cognitive abilities and learning styles can impact the effectiveness of interventions. Different students may respond differently to specific interventions, suggesting the need for personalized approaches.

These studies highlight some of the challenges and limitations in interventions for addressing math anxiety. The limitations include the focus on cognitive strategies alone, heterogeneity in interventions and outcome measures, the influence of teacher attitudes, and the impact of individual differences in students. Understanding these challenges can inform the development of more comprehensive and tailored interventions.

Implications for Practice

A. Recommendations for educators and practitioners

Based on the existing literature on strategies and interventions for addressing math anxiety, here are some recommendations for educators and practitioners:

1. Foster a supportive and positive learning environment: Create a classroom atmosphere that promotes a growth mindset, encourages risk-taking, and emphasizes effort over outcomes. This can help reduce anxiety and create a safe space for students to engage with mathematics (Ramirez, Gunderson, Levine, & Beilock, 2013).
2. Provide explicit instruction on math anxiety: Educate students about math anxiety, its common manifestations, and strategies to cope with it. By normalizing the experience and

providing tools to manage anxiety, students can develop a more positive attitude towards mathematics (Hembree, 1990).

3. Incorporate relaxation techniques: Teach students relaxation techniques, such as deep breathing exercises or progressive muscle relaxation, that can help reduce anxiety during math tasks (Peng, Xu, & Lin, 2021). These techniques can be integrated into regular classroom routines or used during challenging math activities.
4. Use technology as a supportive tool: Incorporate technology-based interventions, such as educational apps, online resources, or math games, to engage students and provide additional support outside the classroom (Moyer-Packenham & Westenskow, 2013). Technology can offer interactive and personalized learning experiences that cater to different learning styles and pace.
5. Provide ongoing support and feedback: Offer individualized support to students experiencing math anxiety, including frequent feedback, guidance, and opportunities for practice (Ashcraft & Krause, 2007). Personalized attention can help students build confidence and competence in mathematics.

6. Collaborate with parents and caregivers: Involve parents and caregivers in addressing math anxiety by providing resources and guidance on how they can support their children at home (Ramirez et al., 2013). Parental involvement can reinforce positive attitudes towards mathematics and create a cohesive learning environment.
7. Continuously assess and adapt interventions: Regularly evaluate the effectiveness of interventions and make adjustments based on student feedback and outcomes. Flexibility and responsiveness to individual needs can enhance the efficacy of interventions (Meece, Wigfield, & Eccles, 1990).

It is important to note that these recommendations should be tailored to the specific needs and context of the students and educators involved. Collaborative efforts and ongoing professional development can support the implementation of these strategies.

B. Strategies for incorporating effective interventions into mathematics education

Incorporating effective interventions for addressing math anxiety into mathematics education requires careful planning and implementation. Here are some strategies for integrating these interventions into practice:

1. Professional Development: Provide ongoing professional development

opportunities for teachers to enhance their understanding of math anxiety and familiarize them with evidence-based strategies and interventions. This can include workshops, training sessions, and collaborative discussions to build knowledge and skills in supporting students with math anxiety (Hembree, 1990).

2. Individualized Support: Recognize that each student may have different needs and experiences with math anxiety. Implement strategies for individualized support, such as one-on-one meetings with students to discuss their specific challenges and develop personalized strategies for managing math anxiety (Ramirez, 2013).
3. Classroom Environment: Foster a supportive and inclusive classroom environment where students feel safe to make mistakes and ask for help. Encourage collaborative learning activities and provide opportunities for students to share their thoughts and experiences with math anxiety (Dowker, 2004).
4. Explicit Instruction: Provide clear and explicit instruction to help students understand mathematical concepts and procedures. Break down complex tasks into smaller steps, offer guided practice, and provide ample opportunities for students to ask

questions and seek clarification (Ma, 1999).

5. **Use of Technology:** Incorporate technology tools and resources into mathematics instruction to engage students and provide alternative ways of learning. Virtual manipulatives, online tutorials, and interactive apps can help students build conceptual understanding and alleviate anxiety associated with traditional paper-and-pencil tasks (Moyer-Packenham, 2009).
6. **Positive Reinforcement:** Recognize and celebrate students' efforts and progress in mathematics, regardless of their performance. Use positive reinforcement strategies such as verbal praise, rewards, and certificates to boost students' confidence and motivation (Bong, 2008).
7. **Parental Involvement:** Collaborate with parents and guardians to create a supportive home-learning environment. Provide resources and suggestions for parents to help their children with math-related activities and communicate regularly about students' progress and strategies for managing math anxiety (Vukovic, 2013).

By incorporating these strategies into mathematics education, teachers can create a supportive and inclusive learning environment

that addresses math anxiety and promotes positive attitudes and performance in mathematics.

C. Considerations for curriculum development and instructional design

When developing the curriculum and designing instruction to address math anxiety, several considerations can enhance the effectiveness of interventions. Here are some implications for practice:

1. **Incorporate Real-World Applications:** Integrate real-world contexts and examples into the mathematics curriculum to make the subject more relatable and meaningful to students. Linking mathematical concepts to practical applications can help alleviate math anxiety by demonstrating the relevance and utility of math in everyday life (National Council of Teachers of Mathematics, 2014).
2. **Scaffold Learning:** Implement a scaffolded approach to instruction, providing support and guidance as students progress through mathematical tasks. Gradually release responsibility to students, starting with explicit instruction and gradually increasing opportunities for independent problem-solving (Wood, Bruner, & Ross, 1976). This approach can reduce anxiety by providing structured support and building

students' confidence in their mathematical abilities.

3. **Promote Active Learning:** Engage students in active learning experiences that involve hands-on activities, group discussions, and problem-solving tasks. Encourage students to actively explore and manipulate mathematical concepts, fostering a deeper understanding and reducing anxiety associated with passive learning (Bonwell&Eison, 1991).
4. **Differentiate Instruction:** Recognize the diverse needs and abilities of students and provide differentiated instruction to accommodate their individual learning styles and preferences. Offer a variety of instructional strategies, materials, and resources to cater to different learning profiles and promote a positive learning experience for all students (Tomlinson, 2001).
5. **Provide Timely and Constructive Feedback:** Offer timely and specific feedback that focuses on the process rather than just the final answer. Emphasize effort, progress, and strategies used rather than solely on correctness. Constructive feedback helps students develop a growth

mindset and perceive mistakes as opportunities for learning and improvement (Hattie & Timperley, 2007).

6. **Foster a Growth Mindset:** Cultivate a classroom culture that promotes a growth mindset, emphasizing the belief that abilities and intelligence can be developed through effort and practice (Dweck, 2006). Encourage students to embrace challenges, persist in the face of difficulties, and view setbacks as opportunities for growth rather than signs of failure.
7. **Incorporate Metacognitive Strategies:** Teach students metacognitive strategies such as self-reflection, goal-setting, and self-regulation. Help students become aware of their thoughts and emotions related to mathematics and guide them in developing effective strategies for managing math anxiety and optimizing their learning experiences (Zimmerman, 2002).

By considering these aspects in curriculum development and instructional design, educators can create a supportive and empowering learning environment that addresses math anxiety and promotes positive attitudes and performance in mathematics.

Conclusion

A. Summary of key findings and contributions of the review

The review on addressing math anxiety and promoting positive attitudes and performance in mathematics education has provided valuable insights into the impact of math anxiety, strategies and interventions for addressing it, empirical evidence on their effectiveness, and implications for practice. Key findings and contributions of the review include:

1. Math anxiety is a prevalent issue among students and can significantly affect their academic performance and attitudes towards mathematics (Hembree, 1990; Ma, 1999).
2. Cognitive-behavioral interventions, such as self-monitoring, positive self-talk, relaxation techniques, and gradual exposure to challenging tasks, have shown promise in reducing math anxiety and improving performance (Ramirez, Gunderson, Levine, & Beilock, 2013; Wu et al., 2012).
3. Teacher support and classroom interventions, including creating a positive learning environment, providing clear instructions, offering support and encouragement, and using effective instructional strategies, can help alleviate math anxiety and promote positive attitudes (Beilock &

Maloney, 2015; Pajares & Miller, 1994).

4. Technology-assisted interventions, such as educational apps, online resources, and interactive multimedia, can engage students and provide personalized learning experiences, contributing to reduced math anxiety and improved performance (Baker et al., 2010; Kay & LeSage, 2009).
5. Empirical studies have demonstrated the effectiveness of various interventions in reducing math anxiety and improving mathematics outcomes, although the long-term effects and sustainability of these interventions require further investigation (Hembree, 1990; Ramirez et al., 2013).
6. Challenges and limitations in implementing interventions include time constraints, resource availability, and the need for professional development for teachers (Dowker et al., 2016; Ermeling, 2010).

The review contributes to the literature by synthesizing research on math anxiety, providing an overview of effective strategies and interventions, and offering practical implications for educators. It underscores the importance of addressing math anxiety to promote positive attitudes and performance in mathematics education.

B. Future directions for research in addressing math anxiety

Future directions for research in addressing math anxiety should aim to further expand our understanding of this phenomenon and develop effective interventions. Some potential areas for future research include:

1. Longitudinal studies: Conducting longitudinal studies to examine the long-term effects of interventions on math anxiety and academic performance. This would provide insights into the sustainability and lasting impact of various interventions (Cargnelutti, Tomasetto, & Passolunghi, 2017).
2. Individual differences: Investigating the role of individual differences, such as cognitive abilities, learning styles, and socioemotional factors, in the development and alleviation of math anxiety. Understanding how these factors interact with math anxiety can inform the development of tailored interventions (Maloney, Beilock, & Ramirez, 2015).
3. Cultural and contextual factors: Examining the influence of cultural and contextual factors on math anxiety and the effectiveness of interventions. Considering the cultural diversity within classrooms and educational settings can help identify culturally

sensitive strategies and interventions (Meece, Wigfield, & Eccles, 2021).

4. Parental involvement: Exploring the impact of parental involvement and support on reducing math anxiety in children. Investigating strategies to engage parents in addressing math anxiety can provide a comprehensive approach to intervention (Suárez, Cerezo, Núñez, & Rosário, 2018).
5. Technology-based interventions: Further investigating the potential of technology-based interventions, such as virtual reality, gamification, and adaptive learning platforms, in reducing math anxiety and enhancing mathematical performance. Understanding the effectiveness and optimal use of technology in addressing math anxiety can inform instructional design (Jansen, van Leeuwen, & Janssen, 2020).

These future research directions can contribute to the development of evidence-based interventions and strategies for effectively addressing math anxiety and promoting positive attitudes and performance in mathematics education.

C. Overall implications for promoting positive attitudes and performance in mathematics education

Promoting positive attitudes and performance in mathematics education requires a

multifaceted approach that addresses math anxiety and fosters a supportive learning environment. Based on the literature review, the following implications can be drawn for promoting positive attitudes and performance in mathematics education:

1. **Raise awareness of math anxiety:** Educators and practitioners should be aware of the prevalence and detrimental effects of math anxiety. By recognizing the signs and symptoms of math anxiety, they can provide timely support and interventions.
2. **Implement evidence-based interventions:** Utilize effective strategies and interventions, such as cognitive-behavioral techniques, teacher support, and technology-assisted interventions. These approaches have shown promise in reducing math anxiety and improving attitudes and performance in mathematics.
3. **Foster a positive learning environment:** Create a supportive and inclusive classroom environment that encourages students to take risks, make mistakes, and learn from them. Emphasize effort, growth mindset, and the value of perseverance in overcoming challenges in mathematics.
4. **Enhance teacher professional development:** Provide professional

development opportunities for educators to increase their knowledge and understanding of math anxiety and effective instructional practices. Teachers equipped with strategies to address math anxiety can better support students' learning experiences.

5. **Involve parents and caregivers:** Engage parents and caregivers in supporting their children's mathematics learning. Educate them about math anxiety and provide resources and strategies for promoting positive attitudes and addressing math anxiety at home.
6. **Integrate technology appropriately:** Leverage technology to enhance mathematics instruction and provide personalized learning experiences. Virtual reality, gamification, and adaptive learning platforms offer innovative ways to engage students and reduce math anxiety.
7. **Conduct further research:** Continued research is needed to explore individual differences, cultural factors, and the long-term effects of interventions. Future studies can provide deeper insights into effective approaches and shed light on additional strategies for promoting positive attitudes and performance in mathematics education.

By implementing these implications, educators and practitioners can create an environment

that supports students in overcoming math anxiety, developing positive attitudes towards

mathematics, and achieving better academic performance in this critical subject.

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